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MECHANISM OF GOVERNMENT IN A DEMOCRACY

THE proliferation of government and quasi-government activities, including problems inherent in nationalized industries, all compel attention to the question of the structure of government, centralization and accountability. Even if Mr. Harold Macmillan finds the measure of agreement which he stipulates as a condition for taking up the question of local government reform, he is likely to be confronted with problems of regional and central administration demanding clear thinking and prompt and firm decision, as is apparent, for example, from Mr. D. N. Chester's study of the financial and administrative relations of central and local government.

It is all to the good that fresh material for the public discussion of the wider and fundamental issues should continue to be forthcoming, if not by Government action, at least from impartial and authoritative sources. The survey of "British Government since 1918", which appeared two years ago, has been followed recently by a like survey limited to Parliament itself*; and, besides two recent broadcasts in which Mr. Christopher Hollis and Mr. John Strachey have discussed the position of parliament in relation to the party system and the survival of democracy, a recent book by Prof. G. W. Keeton, "The Passing of Parliament", has stated even more cogently the argument advanced three years earlier by Mr. Hollis in "Can Parliament Survive?". Fundamental issues in the functioning or survival of democratic institutions have been raised by discussions at the Present Question Conferences on "Freedom and Responsibility", "People at Work" and "Leadership in a Free Society", and also in studies like those on the nationalized industries by the Acton Society Trust, of Dr. Joseph Goldstein on the government of British trades unions, of Dr. W. H. Scott on industrial leadership and joint consultation, and of Mr. J. F. Scott and Mr. R. P. Lynton on management in its social context.

The position the Government has adopted in regard to the renewal of the Supplies and Services (Transitional Powers) Act, 1945, and the Expiry Laws Continuance Bill, makes consideration of the underlying issues a matter of urgency. The Home Secretary indicated on November 20 that the Government is very willing that an inquiry should be held into the procedures for exercising parliamentary control over delegated legislation. The inquiry, however, should be conducted by a more influential body than the Select Committee of the House of Commons suggested by Sir D. Maxwell Fyfe.

What is required is a thorough survey of the problem, comparable with that made twenty years ago by the Committee on Ministers' Powers under the chairmanship, first of Lord Donoughmore and

* Parliament: a Survey. By Lord Campion, L. S. Amery, D. W. Brogan, J. J. Craik Henderson, Sir Arthur Salter, H. E. Dale, Ivor Thomas, F. W. Lascelles, E. C. S. Wade, Sir Cecil Carr, A. L. Goodhart, G. M. Young. Pp. 296. (London: George Allen and Unwin, Ltd., 1952.) 22*s.* 6*d.* net.

then of Sir Leslie Scott. The multiplication of controls through war-time or security demands, as well as the increased responsibilities which the State has assumed by social legislation and economic stringency, makes it imperative to provide Parliament with some means of supervising really important emergency regulations more effectively than the power merely to accept or reject them outright. It is equally imperative to check any tendency for controls to proliferate.

Credit should be given to the present Government for an attempt to classify and sift the regulations and powers it proposes to retain; but this is no substitute for the process of analysing those powers and defining their scope and purpose, and their relation to the part which the State should play in the society and economy which the Government in power envisages. The vigilance in regard to individual liberties and rights manifested in the debate in the House of Commons on November 20 may nevertheless induce the Government to look again at the whole problem before coming to the House another year and asking for renewal of these Acts. Mr. Boyd Carpenter gave specific assurances that the Government would not maintain greater powers than the existing situation demanded, and that the situation would be watched carefully to ensure that excessive powers were neither held nor sought.

The broad question of the safeguards required to reconcile individual freedom as well as the sovereignty of Parliament and the supremacy of the law with national security and the efficient discharge of the responsibilities of government is discussed impartially and at some length in "Parliament: a Survey", not merely by Sir Cecil Carr in his chapter on delegated legislation but also by Prof. E. C. S. Wade in a chapter on the courts and the constitution, and by Mr. G. M. Young in the concluding chapter on the future of parliamentary government. The difficulties are also noted by Mr. L. S. Amery in discussing the nature of British parliamentary government and by Mr. J. J. Craik Henderson in considering the dangers of a supreme parliament, as well as by Lord Campion, who contributes chapters on parliament and democracy and on parliamentary procedure. Although the protest may be less emphatic than those of Prof. G. W. Keeton or Mr. Hollis, it is no less firm; and in this book it has the further merit of being accompanied by constructive criticism.

Chiefly, such criticism comes from Mr. G. M. Young. Mr. Young sees no prospect of any change in the fundamental composition of the House of Commons, but leans to the idea of some collateral chamber, not exactly on the lines of the industrial parliament suggested by Mr. Hollis, and earlier still by Mr. Churchill in his Romanes Lecture of 1930 and by Mr. Harold Macmillan. He seems to have in mind a body in which group representation of such interests as the universities, local government authorities, and the like would provide the means for a regular and well-informed review of primary legislation and at the same time perhaps also a solution of the difficult problem of the relations between the national boards, Parliament, the trades unions and others. Besides this, he suggests that a committee on statutory instruments should be constituted, on similar lines to the Public Accounts Committee, with the duty of reviewing secondary legislation. Supplemented by regular, informal conferences between Ministers and their chief officials and interested groups in Parliament and the appointment of a Minister of State as 'general visitor' of the Civil Service, and assisted by a rotating team of experienced Civil servants, Mr. Young thinks we might well achieve a running audit of our administration and supply a steady wind of mutual intelligence and understanding, sufficient to keep the atmosphere clean and lively.

These interlocked proposals might well secure the essential conditions required to make the Select Committee Mr. Young proposes effective; but they promise little relief of Parliamentary time. That is a main problem, and while the contributors to this book in general fully recognize that an excessive burden is at present placed on Parliament—partly in consequence of legislative programmes in excess of the capacity alike of Parliament and the Civil Service—surprisingly little is said as to the possibility of devolution in some form or other, or of a vigorous reform of local government which might bring new life and efficiency to local institutions.

The view so strenuously urged by Mr. Hollis that we need to find a means of returning from the professional politician of to-day to conditions in which the average member of Parliament is able to take an active part in the life of the community, and is no longer called upon to sacrifice everything else to his Parliamentary duties, finds little support. Bagehot wrote in 1868: "The great defect of the House of Commons is that it has no leisure". We can scarcely hope to go back to a position in which Parliament only sits for a small part of the year—Burke's essential condition for Parliamentary government to be tolerable; but we must at least, if Parliament is to survive, provide the conditions in which a member of Parliament can respect Burke's great principle that he owes his electors not his industry only, but also his judgment, and that he betrays, instead of serving, them if he sacrifices it to their opinion.

Nevertheless, the contributors to this book agree with Mr. Hollis that the growth of party discipline is deadening and dangerous. The diminishing independence of members of Parliament may well tend to depreciate their quality; but the immediate issue is that, while there is general belief here and elsewhere in parliamentary traditions, Government powers can scarcely be curbed and controlled unless, as Prof. Wade rightly suggests, Government supporters themselves own a higher loyalty than party. Such opposition to Government action may demand a great sacrifice by a supporter of the party in power; but both Mr. Hollis and Mr. Strachey, in their broadcasts, were in agreement that on occasion such a revolt is both necessary and justifiable if democracy is to survive. It is, in fact, on such a spirit that the survival of Parliament and of democratic institutions depends. Devices for reducing the demands on Parliamentary time, for the devolution of functions to local, regional or even functional bodies, for the

resolution of the problems of co-ordinating an increasing number of Ministries and Departments of State and for securing efficient public accounting and departmental efficiency, can only have their full effect when both Parliament and the Cabinet are inspired by a belief in democratic processes and respect Parliamentary tradition and procedure. Unless responsibility and power are thus allied, there are no effective safeguards, nor is it easy to see how even much more drastic constitutional changes than are here suggested could prove adequate. Ultimately, it depends on the extent to which not only Parliament but also the electorate generally understands what is involved, respects the democratic process and parliamentary procedure and is vigilant and resolute to act against any abuse, no matter what party considerations or private interest may require to be sacrificed.

In spite of its failure to relate, in any adequate sense, the functioning of Parliament itself with that of a virile system of local government, the book does bring out the dependence of Parliament on public understanding and support rather than on any system of checks and counter-checks. Less than justice is possibly also done to the need for wise and efficient central government, and no great contribution is made to the thinking out of how mutual intelligence can be made to permeate and ultimately to control the relations between Government and people. But on the price to be paid for the survival of Parliament, and of liberty as we understand it in a democratic State, there is a large measure of agreement, and that price is clearly indicated.

Mr. Craik Henderson insists, for example, that loyalty to something greater than party is the final safeguard against the abuse of executive or parliamentary supremacy. Prof. E. C. S. Wade sees in vigilant and enlightened criticism the only sure safeguard, outside the limited field controlled by the courts, against abuse of power by the executive, and Sir Cecil Carr calls for the "inbred insubordination" and "natural impulse" to resist authority with which Bagehot characterized the English people. Above all, the consistent protest against the abuse of party is accompanied by plain warning that there is no mechanical way of preserving democracy—the real dangers are within. No system of organization, however efficient, will preserve the form and spirit of democracy if there is lacking either vigilance or the will to act resolutely against abuse by those who reject the democratic tradition. If the pursuit of party policy is once placed above the sanctity of the democratic process of discussion, consultation and 'give and take', it is a short step to totalitarian tyranny.

These essays could contribute something to that vital task of education required for a clear understanding by the general body of the electorate of the nature and functioning of Parliamentary government in Britain and the conditions for its survival and success. They should also discourage efforts to make Parliamentary institutions more rigid, thus reducing the inherent flexibility which is part of their strength. At the same time, they help to bring home to every reader the need not only for vigilance against abuse but also for self-discipline, in order that the tradition and privilege of freedom may be preserved both in Parliament itself and in re-invigorated local government institutions. The reconciliation of power and responsibility is never finally achieved: it endures so long, and only so long, as the electorate is able and willing to discriminate between the true and the spurious, and is not deluded by whatever screen of propaganda may be spread by those who seek to pervert or destroy Parliamentary institutions.

ANTOINE LAVOISIER

Antoine Lavoisier

Scientist, Economist, Social Reformer. By Dr. Douglas McKie. Pp. viii+335+18 plates. (London: Constable and Co., Ltd., 1952.) 30*s*. net.

LAVOISIER'S fame as "the founder of modern chemistry" has overshadowed his achievements as an administrator, a social reformer and an economist. These have had comparatively little attention, although his scientific work only took a fraction of his busy day, and from time to time he was occupied entirely with his other tasks.

Dr. Douglas McKie's earlier biography, published seventeen years ago, dealt mainly with Lavoisier's great reform of chemistry, comparable with the contribution of Newton to mechanics and astronomy and of Darwin to biology. Now the author has again earned our gratitude by this new life, with its comprehensive picture of Lavoisier's varied activities, which will be new to most readers. About a third of the book is devoted to Lavoisier's scientific work, and here Dr. McKie breaks little fresh ground. This must wait presumably for the publication of his laboratory notebooks.

When he turns to Lavoisier's record of public service, Dr. McKie's scholarly studies of French social history and politics in the eighteenth century give us an intimate picture of the background of Lavoisier's work. Lavoisier was only twenty-five when he "took the most fateful, and indeed ill-fated, step in his life" by joining the Tax-Farm, a financial corporation that leased from the Government the privilege of collecting the indirect taxes. He soon became one of its most efficient administrators and was constantly striving to remedy abuses and eliminate waste. His business journeys and his observant eye gave Lavoisier an unrivalled knowledge of social and economic conditions in France, and the statistics he collected through the officials of the Tax-Farm made possible his report on "The Territorial Wealth of France", which was a pioneer effort in national statistics giving for the first time an accurate estimate of the national income and its taxable limits. As the *Moniteur* said, "the work comprised in small compass the whole basis of political economy".

For seventeen years Lavoisier was one of the commissioners in charge of the production of gunpowder. He lived at the Arsenal, where again his organizing ability and his rapid drafting of reports and instructions were invaluable. Production was increased, great economies were made and the range of French weapons was increased by 60 per cent. He knew the miserable conditions of French agriculture, and in 1778 he bought an estate at Fréchines and

started an experimental farm with the object of improving the most vital of all French industries. Dr. McKie describes the skill with which Lavoisier applied to farming the scientific analysis that marked all his researches and the great improvements in farming methods that he achieved.

When provincial assemblies were established in 1787, Lavoisier was elected a member of the assembly of Orléanais, and he was soon its outstanding figure. He saw so clearly the reforms that were long overdue: his memoranda on the *corvée*, on the state of agriculture, on old-age insurance, on savings banks and on the need for a geological survey show his modern outlook and his vision and imagination. Even in the dark days of the Revolution he never relaxed his efforts for France; in 1793 he presented a report to the National Convention on national education, envisaging the complete democratization of opportunity with free primary education for all children. He foresaw, too, the need for science and industry to work together. "Much that he urged in the organization and application of science has been realised only in our own time."

Dr. McKie tells the sad story of the final tragedy, adding fresh evidence about a packet of letters "written in English" which might have contributed to Lavoisier's death. This book gives an admirably balanced story of Lavoisier's many-sided life. It is written with fullness of knowledge, with great sympathy and understanding, and has the lucidity that characterized the writings of Lavoisier himself. It is clearly destined to be a standard history of Lavoisier's unique record of intellectual and practical achievement.

Harold Hartley

BIRTH AND GROWTH OF EXPLOSIONS

Initiation and Growth of Explosion in Liquids and Solids

By F. P. Bowden and A. D. Yoffe. (Cambridge Monographs on Physics.) Pp. xii+104+5 plates. (Cambridge: At the University Press, 1952.) 22*s*. 6*d*. net.

GREAT progress has been made during the past twenty years in the understanding of propagation of detonation in condensed explosives by the development of the hydrodynamic theory of detonation. This theory is purely mechanical, and like thermodynamics it has no curiosity, so that it tells us nothing about the nature of the decomposition or reaction of the explosive itself. It is all the more important, therefore, that collateral experimental work on the nature of the initiation and growth of explosion in condensed explosives should be prosecuted vigorously. Dr. F. P. Bowden and his school have carried out such work, first in Australia (with the then Commonwealth Council for Scientific and Industrial Research) during the Second World War and afterwards in Cambridge in the Research Laboratory on the Physics and Chemistry of Surfaces, and the results of the work are collected in the present monograph written by him in collaboration with Dr. A. D. Yoffe. Bowden's interest in explosives arose naturally from his work on the friction and lubrication of solids, which is described in a recent monograph written with Dr. D. Tabor as co-author (see *Nature*, **167**, 252; 1951). It was natural to utilize similar techniques for the study of the decomposition of explosives since these have always been tested by the now classical empirical tests involving impact and friction. Bowden and his school have, however, made a major advance in the understanding of the phenomena of the birth and growth of explosions in small quantities of material by demonstrating very elegantly that initiation is due to the formation of 'hot spots' of small but finite size in the explosive, and that such 'hot spots' are readily formed by adiabatic compression of minute gas-pockets trapped in the explosives. It is the essential simplicity of the disclosed mechanism which makes it such a valuable contribution.

The introductory chapter deals with the two principal theories of initiation of explosives by mechanical shock, namely, the tribochemical and thermal theories. As a result of their investigations, the authors favour the thermal theory and demonstrate that usually initiation is produced by the formation of a local 'hot spot'. Effective 'hot spots' can be produced in several ways; but the most important were found to be boundary friction between solid particles of high melting-point at points of rubbing contact, and adiabatic compression (and consequent heating) of minute gas or vapour bubbles in the explosive. The last chapter of the book deals with the growth and propagation of explosions from these minute 'hot spots'.

The book is illustrated with numerous photographs taken on rotating-drum cameras and showing the development of the explosion in various substances. In a considerable number of cases the 'hot spot' is succeeded by a phase of burning before detonation ensues, but in certain cases detonation ensues immediately after the 'hot spot'.

The book is readable and the arguments are readily followed; but it could have been more valuable to the specialist if more detailed and quantitative descriptions of the ingenious apparatus and methods used had been given. Nevertheless, the monograph is a very useful contribution to the literature and will be welcomed by both research workers and technicians in the explosives field.

James Taylor

HEALTH EDUCATION TO-DAY

Health Education

A Guide to Principles and Practice. By Cyril Bibby. (Heinemann Education Series.) Pp. x+222. (London: William Heinemann, Ltd., 1951.) 17*s*. 6*d*. net.

WHAT should be expected of health education to-day? Many valuable and useful manuals of hygiene exist giving us the facts of health and health education; but a well-considered account of the judgment of the present-day experienced experts on the principles and practice of health education has been wanted for some time. In this book Mr. Cyril Bibby has now written such an account, and many will be most rewarded by a first perusal and subsequent constant reference. To-day we have reached that point in health education where our principles must be put into practice (even if improvisation is still often required through lack of funds or resources), otherwise the facts of health which we offer to individuals in the communities of to-day will fail to produce any lasting or worth-while effect. This is a particularly salient comment for the teachers of the young of all age-groups; for sister tutors in the training schools; for the teachers of future medical

men and women; and especially for lecturers in health education in the training colleges for future teachers. Every individual passes through some teacher's hands at some time or other, and it is absolutely essential that all teachers, not just the scientific worker or the physical educationist, should know what part they can play towards inculcating habits, imparting information, fostering attitudes and responsibilities, and inspiring ideals for a balanced harmony in living. Thus the physical, mental, emotional and social aspects of health should be woven together for the individual within the community. To-day we are convinced that the immunization of babies and young children against diphtheria has reduced child mortality from diphtheria and lessened human suffering and sadness. Yet to-day there is a very great danger that parents are not going to practise the principle of diphtheria immunization for their children, because they do not appreciate the necessity for it or because they are apathetic. Hence the latest diphtheria poster "If——"; hence health education and its modern emphasis; hence the value of the book under review.

This book should be in the library of all teaching institutions—the training colleges for teachers and social workers, and the medical and nursing schools—because it is a book for educators, both lecturers and those students who are preparing themselves as widely as possible to be of use, example and inspiration to their future flocks. Some students and all teachers of health education should possess this book as a comprehensive reference book, while public libraries could well stock the book for members of the public and for those parents who will seek such information as it reliably gives.

Mr. Bibby has divided his book into two parts. The first part consists of eight readable chapters emphasizing sanely and in a manner fully approved by present-day pioneers what is really implied by health education to-day. It deals with aims, aspects, facts, media and with health education in the home, school, college and community. The second part consists of most valuable appendixes of schemes, curricula, syllabuses and programmes with a seasonable bias, together with a directory of health education organizations, useful statistics, recommendations for films, film strips, books and other media, all of which will be much appreciated by busy teachers and lecturers.

If we know whither we want to go, this excellent book will probably tell us the way from our present stage; if our aims are not really up to date, it will start us on the right road in health education.

P. M. Taylor

BOTANY OF THE SCOTTISH HIGHLANDS

Plant Life in the Scottish Highlands

Ecology and Adaptation to their Insect Visitors. By Alexander Edward Holden. Pp. xv+319+64 plates. (Edinburgh and London: Oliver and Boyd, Ltd., 1952.) 30*s*. net.

THOUGH the flora of the Scottish Highlands is comparatively poor as regards the number of species represented, this relative poverty is more than compensated by the interest and rarity of many plants which are not found elsewhere in Britain. The occurrence, distribution and affinities of the local species present some of the most fascinating problems connected with the British flora, and a systematic account of Highland botany dealing authoritatively with all aspects is long overdue.

The title and price of the work now under review suggest that this subject has at last been adequately treated. The book will certainly whet the appetite of field botanists, nowadays a vigorous and knowledgeable body in Britain, who at some time or other must visit the Highlands of Scotland if they wish to see species not occurring elsewhere. But, to students of the British flora, it will be a great disappointment, and particularly to those who have enjoyed memorable days plant-hunting in the Scottish mountains, and exciting hours afterwards in identifying their specimens. The professional botanist, and many amateurs also, will find little, if anything, original in the author's observations; but, on the other hand, will have much to criticize. The informed reader with a knowledge of plants and their ways will be rather chary of accepting the author's invitation early in the first chapter to regard plants "as sentient beings with hopes and fears and ambitions much like our own". This teleological theme is not a promising approach to the study of the vegetation of the Highlands, and it sets the tone of the whole work, which can scarcely be regarded as a serious contribution to the study of Scottish botany. It is quite clear that modern advances in the taxonomy of the British flora and the recent exciting discoveries of new plants in the Highlands have completely escaped the author's notice.

No attempt is made to give a scientific appreciation of the alpine and other habitats mentioned, and their plant communities, and the ecologists will have to look elsewhere for a critical appraisal of the physical conditions which influence plant life in the Highlands. The author deals with the vegetation in a most arbitrary way by selecting various habitats and describing rather cursorily one or two typical species.

The book will not greatly assist a beginner in the identification of plants, and it is necessary to point out that the nomenclature and taxonomy are often widely at variance with modern concepts. The serious divergences are too numerous to deal with in detail, and it is unfortunate that there are so many misleading statements that the author's generalizations must be read with caution. Nor are the distributional data always reliable, and one or two confident statements certainly need modification. It is no longer true that *Saxifraga cernua* is confined in Britain to the broken schist near the summit of Ben Lawers (p. 18); *Pinguicula alpina* (p. 194) has been extinct (since the beginning of the century) at its only certain Scottish station; and *Eriocaulon septangulare* (p. 222) is much more widely spread in Ireland than indicated, and the localization of the plant in Scotland is only partially correct.

A small chapter of four pages is considered sufficient to deal with the important aspects of distribution and affinities of the flora. As a result of this severe compression the picture of the sequence of geological events and climatic changes which have influenced the plant life of the Highlands is confused, and, in several respects, unsupported by scientific evidence.

It is a pity that this book cannot be recommended as an acceptable work on the vegetation of the Scottish Highlands. The typography is excellent and a wide selection of magnificent monochrome photographs by Mr. R. M. Adam illustrate many of the species and their habitats.

George Taylor

A Textbook of Evolution

By Prof. Edward O. Dodson. Pp. xviii+419. (Philadelphia and London: W. B. Saunders Co., 1952.) 5 dollars; 25*s*.

THE past few decades have seen very noteworthy contributions to the study of evolution by such authors as Dobzhansky, Goldschmidt, Simpson, Mayr, Huxley, Haldane, Wright and others, but there are few text-books in which this modern work has been summarized in a form suitable for students in the first two years of their university career. This is the gap which E. O. Dodson has attempted to fill for American students, as G. S. Carter has for British. The book under notice is characterized by extreme clarity of exposition, both of the theoretical problems involved and of the factual material. It does perhaps attempt rather too much in some respects. Is it possible to summarize the whole comparative anatomy of the animal and plant kingdoms, from viruses up to the primates, in about 130 pages? Is it even necessary in a text-book devoted to evolution? British students of zoology, at any rate, will deal with such topics more fully in other parts of their course. The most valuable part of the book is the fourth, which is devoted to the recent studies on natural selection, species formation and similar evolutionary mechanisms. This contains a selection, on the whole judiciously made, of material which can otherwise only be found in original papers or books addressed to a much more advanced audience. The book is well illustrated and has a good index.

Government Information and the Research Worker

Lectures delivered at a Vacation Course of the University of London School of Librarianship and Archives in April 1951. Edited with an Introduction by Ronald Staveley. Pp. vi+228. (London: Library Association, 1952.) 24*s*.; to members of the Association, 18*s*.

A PAPER by Mr. W. Cox on "H.M. Stationery Office Publications", given at the Aslib Conference in September 1949, provoked some discussion on Government publications. The subject was also raised at subsequent meetings of Aslib, both in Glasgow and in Manchester, in the following year, when difficulties being experienced in locating or obtaining such publications were stressed. In the following year a series of lectures, dealing with the resources of the major Government ministries and departments likely to be of value as sources of information to the research worker, were delivered at a vacation course of the University of London School of Librarianship and Archives. The interest taken in this course, which was attended by more than a hundred librarians and information officers, has now led the Library Association to publish these lectures, with the exception of two.

These exceptions, however, are important. The first was Mr. E. M. Nicholson's introductory address on "The Government and Research", and the second was that in which Dr. W. R. Francis described the present Government agencies and departments in which scientific research is undertaken or sponsored. These lectures are omitted at their authors' request because the subjects have since been covered in the official pamphlet "Government Scientific Organisation in the Civilian Field". Accordingly, the claims of the book on the interest of the scientist are slender, and are largely limited to Dr. D. J. Urquhart's brief chapter on the "Department of Scientific and Industrial Research as a Source of Information for Research Workers", and Mr. L. R. Poole's account of "The Technical Information and Documents Unit". The account of the research resources of the Ministry of Supply is also brief, due to the same security requirements which led to the omission of the three Service Ministries and the Ministry of Civil Aviation. This is not to say that the scientist or technologist will not find the accounts of some other departments, such as the Ministry of Fuel and Power or the Ministry of Works, of interest; but, by and large, the book is mainly of interest to the social scientist rather than to the scientist in general.

Subject to the omissions mentioned above the book covers the ground fairly thoroughly, and the various chapters bring out the extent to which the needs of both librarian and research worker are appreciated at a high level in most ministries, and the extent to which the departments are anxious to be of service. R. B.

Avicenna, Scientist and Philosopher

A Millenary Symposium. Edited by G. M. Wickens. Pp. 128. (London: Luzac and Co., Ltd., 1952.) 15*s*.

IN the year A.D. 980 was born within the borders of Afghanistan one who came to be nicknamed Ibn Sina. During the fifty-seven years of his life he became a figure of world renown in the person whom the medieval schoolmen called Avicenna. A Persian of the Persians, he was an intellectual prodigy, poet, mystic, medical man and *bon viveur* all rolled into one. Alas, he was not devoid of conceit, combined with a curiously refined arrogance. His influence through the ages has been tremendous, as this collection of lectures delivered at Cambridge in his honour abundantly proves. The six speakers comprised two Arabists, two Hebraists, a scientist-philosopher, and a modern linguist—surely an appropriate team.

By them we are given an insight into Avicenna's life and work; an estimate of his place in Asiatic philosophy; an account of some aspects of his activities; an appraisal of his influence upon Jewish thought, and upon medieval scientific tradition; and finally, a description of the effect he had upon the thirteenth century, more especially, of course, upon St. Thomas Aquinas. Compact references accompany the text.

Avicenna, who contributed to metaphysics the concept of a necessary Being whose essence and existence were identical, was the same person who experimented with many drugs, and demonstrated his mastery of the inductive method. Authors and publishers have done well to pay him homage in producing this first-class book. F. I. G. Rawlins

Green Thoughts

By Sir Stephen Tallents. Pp. 192. (London: Faber and Faber, Ltd., 1952.) 15*s*. net.

THOSE who enjoy Sir Stephen Tallents's essays in periodicals and newspapers will be delighted to have this collection in more permanent form.

The anthology covers a wide range of country topics and pursuits around the year, and they are described with characteristic charm. One feels throughout that Sir Stephen's affection for his wood-fed fire, his crooked rake and beloved scythe, are part of the heritage of the venerable sanctuary which is now his home. The chapters on moles and nettles are particularly rewarding; but the final essay on scything is surely the most complete memoir of the art and theory of that ancient practice.

ACCELERATION OF HEAVY IONS TO HIGH ENERGIES

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SINCE the first development of the cyclotron by Lawrence and Livingston in 1931, relatively little attention has been paid to the acceleration by its means of ions heavier than ^{4}He. It was natural enough in the development of nuclear physics that attention should first have been given to the information which could be obtained by the bombardment of nuclei with the simplest possible particles; and rightly, the emphasis is still the same to-day. However, the study of fast heavy ions is of interest on its own account. Such ions occur in nuclear disintegration and recoil processes, and in the fission of heavy elements. Interest in them was stimulated by the discovery of nuclei of medium atomic number in the primary cosmic radiation by Freier *et al.*[1] in 1948. As bombarding particles for producing nuclear transformations, heavy ions accelerated in a cyclotron may prove of value in particular problems as, for example, the production of transuranic elements[2,3]. Here the product nucleus desired might differ greatly in mass and charge from the available target nucleus. Recently, Breit *et al.*[4] have pointed out that it might be possible to obtain specific information on nuclear structure, which cannot readily be obtained otherwise, by bombarding nuclei with energetic heavy ions.

Technical Considerations

Three main differences may be noted when we compare the acceleration of heavy ions in a cyclotron with the acceleration of hydrogen or helium ions.

First, since the binding energy of the K-electrons in an atom varies as the square of the atomic number, it becomes increasingly difficult with the heavier atoms to produce high states of ionization directly in, or near, the ion source of the cyclotron. Indeed, this effect is already apparent if we compare hydrogen and helium, since it is well known that the beams of doubly-charged helium which can be obtained in a cyclotron are less than the corresponding beams of singly-charged deuterium. Now we are interested in producing highly-charged ions because the energy which can be imparted to an ion of a particular mass, using a given cyclotron magnet, increases with the ionic charge. This follows from the relation $p = Ber$, in which p is the momentum of an ion of charge e at a radius r where the magnetic induction is B. With highly-charged ions it is possible, in a fixed-frequency cyclotron 60 in. in diameter, to produce ions energetic enough to penetrate the Coulomb barrier of even the heaviest nuclei. The Birmingham cyclotron of this diameter can produce ions with energies of about $10A$ MeV., where A is the atomic mass number.

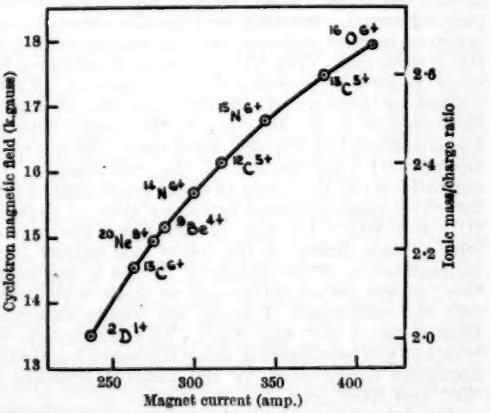
Secondly, the mass-to-charge ratios of ions of stable isotopes heavier than helium-3 are all greater than that of the deuteron (except for fully stripped nuclei which contain equal numbers of protons and neutrons). The angular frequency (ω) of an ion in a cyclotron is given by $\omega = B(e/m_0)(1 + E/m_0c^2)^{-1}$, where m_0 is the rest mass of the ion and E its kinetic energy. Consequently all the heavier ions, with the exceptions noted, have a larger ratio (B/ω) for the same E/m_0c^2 than does the deuteron. For resonance with a given cyclotron radio-frequency, B may be much larger than that required for the deuteron, as can be seen from the accompanying graph.

Thirdly, not all elements heavier than helium can be obtained in gaseous compounds suitable for the conventional gas-discharge ion-source used in cyclotrons. Thus in some cases, as for example beryllium-9, solid sources of ions must be used.

Work in the United States on the Acceleration of Heavy Ions

The pioneering work on the acceleration of ions heavier than ^{4}He, as in so many other branches of cyclotron technique, was carried out at the Radiation Laboratory of the University of California at Berkeley. The first work was reported in a brief abstract by Alvarez[5] in 1940. He used the fixed-frequency cyclotron of 37 in. diameter, the cyclotron chamber being filled with methane. A beam of $^{12}C^{6+}$ ions of about 50 MeV. was detected by means of a proportional counter and linear amplifier. Since the resonances of $^{12}C^{6+}$ and $^4He^{2+}$ ions lie close together (the mass-to-charge ratios of $^{12}C^{6+}$ and $^4He^{2+}$ differ by only one part in 1,500), care had to be taken to resolve the $^{12}C^{6+}$ beam in the presence of the helium contamination of the cyclotron. To do this clearly, it was necessary to operate with the cyclotron magnetic field below the optimum value for the acceleration of $^{12}C^{6+}$, and this led to a weak beam of only about 500 carbon ions per minute. Further work with the Berkeley 60-in. cyclotron, reported briefly by Condit[6] and by York *et al.*[7], led up to the work of Miller *et al.*[3] with the same machine. The last-named authors used a hooded capillary ion-source fed with carbon dioxide gas. They obtained external beams of 10^5 ions per sec. of $^{12}C^{6+}$ at 115 MeV. and, using carbon dioxide enriched to 50 per cent carbon-13, of 10^4 ions per sec. of $^{13}C^{6+}$ at 122 MeV. They estimated an internal beam of $^{12}C^{6+}$ of about 10^8 ions per sec.

Recently, Chou *et al.*[8], using the Chicago synchro-cyclotron, have accelerated carbon ions to energies as high as 1,100 MeV. They mention the acceleration



Magnetic field plotted against magnet current for the Birmingham cyclotron. Heavy-ion resonances are observed to occur at the magnet currents indicated. For the cyclotron frequency of 10·31 Mc./sec., the ionic mass-to-charge ratios calculated to give resonance with the magnetic field are shown on the right-hand scale. Mass-to-charge ratios are expressed as (atomic mass) ÷ (number of electron charges)

of $^{13}C^{5+}$ ions as well as completely stripped carbon ions. Carbon dioxide gas was used in the ion-source. They have also accelerated $^{9}Be^{4+}$ ions, and assumed in this case that the beryllium ions were evaporated from an internal target which is normally subjected to intense proton bombardment when the cyclotron is accelerating protons. The authors do not mention the strengths of beam obtained, but these are apparently at least adequate for the bombardment of photographic emulsions.

Work at Birmingham on the Acceleration of Heavy Ions

In the Nuffield Laboratory at the University of Birmingham, using the 60-in. fixed-frequency cyclotron, we have recently made a study of heavy ion resonances over a wide range of magnetic fields. Resonances due to the following ions, listed in order of increasing mass-to-charge ratio, have been studied: $^{13}C^{6+}$, $^{20}Ne^{9+}$, $^{9}Be^{4+}$, $^{14}N^{6+}$, $^{12}C^{5+}$, $^{15}N^{6+}$, $^{13}C^{5+}$ and $^{16}O^{6+}$. A scintillating crystal (potassium iodide activated with thallium), mounted on a 'Perspex' light guide and inserted between the 'dees' at radii varying from 24 to 27½ in., was used to detect the resonant beams of ions. The crystal was covered with 17 microns of aluminium. At a radius of 27 in. the kinetic energy of an ion, revolving about the centre of the cyclotron with a frequency equal to that of the radio-frequency accelerating voltage (10·31 Mc./sec.), is approximately 10 A MeV., where A is the atomic mass number of the ion. This maximum attainable energy therefore varies from 90 MeV. for beryllium-9 to 200 MeV. for neon-20. For producing carbon ions, the ion-source was fed with carbon dioxide gas, while the source of nitrogen ions so far has simply been the residual air in the cyclotron tank. To locate the $^{20}Ne^{9+}$ resonance, the ion-source was fed with neon gas. In order to accelerate $^{9}Be^{4+}$, the normal molybdenum tip of the ion-source was replaced by one of beryllium metal, and during some of the runs with the beryllium tip the ion-source was fed with hydrogen gas instead of carbon dioxide. When the cyclotron was running, this beryllium metal tip became heated to a bright red.

The mean magnetic field in the cyclotron is plotted against the current in the magnet coils in the accompanying graph. Superimposed on this curve, at the observed magnet currents, are the resonances due to the various ions. (The $^{2}D^{1+}$ resonance, determined by other means, is included for comparison.) These resonances correspond exactly, for the cyclotron frequency of 10·31 Mc./sec., to the mass-to-charge ratios indicated on the right-hand scale. This provides unequivocal identification of the resonances. The method has not been used to study resonances of ions for which mass-to-charge ratios are close to those of $^{2}D^{1+}$ and $^{4}He^{2+}$, for fear of damaging the crystal with intense beams of the latter ions arising from contamination of the cyclotron. It has in any event been considered an advantage to work with heavy ions the resonances of which are widely separated from those of $^{2}D^{1+}$ and $^{4}He^{2+}$. This eliminates the possibility of experiments, using the heavy ion beams, becoming complicated by the possible presence of $^{2}D^{1+}$ and $^{4}He^{2+}$ ions.

A striking feature noticed was the great prominence of the $^{13}C^{6+}$, $^{14}N^{6+}$, $^{15}N^{6+}$ and $^{16}O^{6+}$ resonances. The $^{13}C^{5+}$ resonance is much weaker than the $^{13}C^{6+}$ resonance, while $^{15}N^{7+}$ and $^{16}O^{7+}$ are not observed at all. It is to be noted that, when the cyclotron is adjusted to accelerate six-charged ions, doubly-charged ions of the same species have a frequency of revolution in the cyclotron which, in the approximation $E \ll m_0c^2$, is one-third of the cyclotron radio-frequency. Doubly-charged ions can thus be accelerated, and at a given radius will have an energy which is one-ninth of that of a six-charged ion if both ions are revolving about the centre of the cyclotron. There can be no doubt that pre-acceleration of the ions in the doubly-charged state (third harmonic acceleration) aids in an important manner in the ultimate stripping of the ions to the six-charged state through collisions with residual gas molecules. Fifth and seventh harmonic acceleration are increasingly less effective for this purpose. Of the still heavier neon ions, only the $^{20}Ne^{9+}$ ion, which fulfils the third harmonic condition, has been so far studied. The use of a scintillating crystal for the detection of the resonant beams makes possible a study of the structure of the resonance curves (the variation of counting-rate with magnetic field), and of the energy distribution of the ions by pulse-height analysis. Evidence from these studies lends support to the theory of third harmonic pre-acceleration. It is intended to publish elsewhere a more detailed account of this study of acceleration mechanisms. Condit[8] and Miller[9] have mentioned that harmonic acceleration can take place with carbon ions, but there appears to be no mention in the published literature of its possible importance for subsequent electron stripping.

In the case of $^{9}Be^{4+}$, odd harmonic pre-acceleration is not possible. However, it is felt that, owing to the comparatively low atomic number of beryllium, it is relatively easy to get the atoms fully stripped without recourse to harmonic pre-acceleration. The observed fact is certainly that beams of $^{9}Be^{4+}$ can be readily obtained which are at least as good as the beams of $^{13}C^{6+}$ obtained when carbon dioxide of normal isotopic constitution is used in the ion-source.

The Birmingham work has not so far explored the upper limits of beam-strengths obtainable. On strong resonances it is easily possible to saturate the counting system with counting-rates in excess of 10^4 per sec. At this stage we must take the work of Miller *et al.*[3], mentioned above, as an indication of beam-strengths which have been obtained in a similar cyclotron. The beam-strengths used at Birmingham so far are more than adequate for bombarding photographic emulsions internally in the cyclotron. In the case of $^{9}Be^{4+}$, bombardment of emulsions has also been carried out with a deflected external beam. In this connexion it is worth noting that, with increasing mass-to-charge ratio, higher deflecting voltages are required to produce external beams.

Harmonic pre-acceleration might well be important in helping to obtain large beams of heavy ions. An alternative scheme, for injecting heavy ions into a synchrocyclotron or a heavy-particle synchrotron, has been put forward by Tobias[10]. A linear accelerator would pre-accelerate ions carrying a low charge. These ions would be injected into the synchrocyclotron or synchrotron, tangentially to a desired orbit, and would be fully stripped at the orbit by passing them through a thin foil.

Experimental Studies with Heavy Ion Beams

The study of a number of problems has been made possible by the successful acceleration of heavy ions, and exploratory work on some of these problems has been reported.

Miller *et al.*[2] have reported observing the nuclear reactions $^{27}Al(^{12}C,\alpha n)^{34}Cl$ and $^{197}Au(^{12}C,4n)^{205}At$ with 115-MeV. $^{12}C^{6+}$ ions. The possible value of such reactions in the production of transuranic elements, where a large change of nuclear charge and mass is required when bombarding an available isotope, is obvious. Ghiorso *et al.*[3], using 120-MeV. $^{12}C^{6+}$ ions, have obtained small yields of californium-244 from the reaction $^{238}U(^{12}C,6n)^{244}Cf$ and report also that californium-246 is probably obtained by the reaction $^{238}U(^{12}C,4n)^{246}Cf$ with a comparable cross-section.

Miller[9] has reported a preliminary study of the nuclear interactions of 120-MeV. ^{12}C ions and 130-MeV. ^{12}C ions in photographic emulsions. External beams of $^{12}C^{6+}$ and $^{12}C^{5+}$ ions from the Berkeley 60-in. cyclotron were used. In exposing the emulsions, a slit system was used to eliminate contaminating particles. Using for the purpose of the calculation the full lengths of the carbon tracks in the emulsion, he finds the cross-section for inelastic nuclear events in which charged particles are emitted to be $(0{\cdot}40 \pm 0{\cdot}03)$ barn for ^{12}C and $(0{\cdot}37 \pm 0{\cdot}03)$ barn for ^{13}C. A feature of the nuclear explosions (stars) is the large number of α-particles emerging. The maximum number of prongs observed in a star was seven. A photograph of this star appears with his communication. It was caused by a carbon nucleus slowed down in the emulsion to 90 MeV. We have also observed, at Birmingham, stars produced in photographic emulsions by ^{9}Be, ^{13}C and other ions.

Giles and Barkas[11] have reported a preliminary study of the pick-up of electrons by ^{12}C ions as they slow down in photographic emulsions. This study was carried out by counting the varying number of gaps in the tracks recorded in Ilford *D*-1 emulsions. The number of gaps is related inversely to the ionization density, which in turn is related to the mean charge carried by the ion. Such investigations should provide a check on the theories[12–15] which relate the mean charge carried by an ion passing through matter to the velocity of the ion. These theories were developed originally in a study of the range–energy relations of fission fragments and recoil nuclei. Our work in Birmingham has shown clearly the difference in appearance of tracks in photographic emulsions due to such ions as ^{4}He, ^{9}Be, ^{12}C and ^{20}Ne, which are well spaced in atomic number.

Chou *et al.*[6] have studied the density of δ-rays (recoil electrons) along the tracks of energetic carbon and beryllium ions in photographic emulsions. They find agreement with the theory of Mott[16]. This theory was first applied to the tracks of heavy ions of the primary cosmic radiation by Bradt and Peters[17]. To identify the heavy ions, these authors used the fact that the number of δ-rays with energies in a given interval is, in a certain approximation, proportional to Z^2/β^2, where Z is the charge carried by the ion and β its velocity. Chou *et al.*[6] have also studied the multiple scattering of carbon ions at energies up to 1,100 MeV. by the method of Fowler[18] and find agreement with theory[19]. They have also published a photograph of a star, initiated in a photographic emulsion by a 750-MeV. carbon nucleus, in which nine charged particles were emitted.

Breit *et al.*[4], in a theoretical paper, have considered in some detail the nuclear effects which might be expected in bombardments by ions such as ^{12}C and ^{16}O, and have estimated the distortion effects produced in target nuclei by the incident ions. This distortion might be expected to affect the thresholds of reactions which are determined by Coulomb barriers, and also the relative probabilities of emission of the various reaction products which might be observed. One might also expect effects due to the leakage of protons and neutrons out of the two colliding heavy nuclei by wave-mechanical penetration of the regions of negative kinetic energy between the nuclei. If practicable, exploration of the latter effect would amount to a study of the halo of neutrons and protons surrounding the more compact nuclear interior. It might be helpful in determining the number of particles at the nuclear surface having a given energy.

We should like particularly to acknowledge the help of Dr. W. I. B. Smith and Mr. W. Hardy in the work carried out with the Birmingham cyclotron. We are also indebted to Mr. W. T. Link for experimental assistance, and to Profs. P. B. Moon and W. E. Burcham for their interest.

[1] Freier, P., Lofgren, E. J., Ney, E. P., Oppenheimer, F., Bradt, H. L., and Peters, B., *Phys. Rev.*, **74**, 213 (1948).
[2] Miller, J. F., Hamilton, J. G., Putnam, T. M., Raymond, H. R., and Rossi, G. B., *Phys. Rev.*, **80**, 486 (L) (1950).
[3] Ghiorso, A., Thompson, S. G., Street, K., and Seaborg, G. T., *Phys. Rev.*, **81**, 154 (L) (1951).
[4] Breit, G., Hull, M. H., and Gluckstern, R. L., *Phys. Rev.*, **87**, 74 (1952).
[5] Alvarez, L. W., *Phys. Rev.*, **58**, 192 (A) (1940).
[6] Condit, R., *Phys. Rev.*, **62**, 301 (A) (1942).
[7] York, H., Hildebrand, R., Putnam, T., and Hamilton, J. G., *Phys. Rev.*, **70**, 446 (A) (1946).
[8] Chou, C. N., Fry, W. F., and Lord, J. J., *Phys. Rev.*, **87**, 671 (L) (1952).
[9] Miller, J. F., *Phys. Rev.*, **83**, 1261 (L) (1951).
[10] Tobias, C. A., *Phys. Rev.*, **85**, 764 (A) (1952).
[11] Giles, P. C., and Barkas, W. H., *Phys. Rev.*, **85**, 756 (A) (1952).
[12] Bohr, N., *Phys. Rev.*, **58**, 654 (1940); *ibid.*, **59**, 270 (1941).
[13] Lamb, W. E., *Phys. Rev.*, **58**, 696 (1940); *ibid.*, **59**, 687 (1941).
[14] Knipp, J. K., and Teller, E., *Phys. Rev.*, **59**, 659 (1941).
[15] Brunings, J. H. M., Knipp, J. K., and Teller, E., *Phys. Rev.*, **60**, 657 (1941).
[16] Mott, N. F., *Proc. Roy. Soc.*, A, **124**, 425 (1929).
[17] Bradt, H. L., and Peters, B., *Phys. Rev.*, **74**, 1828 (1948).
[18] Fowler, P. H., *Phil. Mag.*, **41**, 169 (1950).
[19] Molière, G., *Z. Naturforsch.*, **3A**, 78 (1948).

POLYPLOIDY IN ANIMALS

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Origins of Polyploidy

IN all cellular organisms, so far as we know, errors in cell division can give rise to cells, tissues and individuals with a multiplied or polyploid chromosome number. Animals and plants have, in general, proved capable of adjusting themselves successfully to a wide range of numbers. In plants not only are nuclei and cells increased in size when the chromosome number is doubled but the individual also. The series haploid–diploid–triploid usually gives a steady, if not a proportionate increase in size of the whole plant, and this may even continue to the tetraploid and beyond. Such an increase is found, of course, only with a genetically uniform chromosome set, without mutations or selection. For if the increase in size is at all disadvantageous to a polyploid race of plants in Nature, selection in later generations can readily reduce it again, and evidently often has done so.

In some animals these rules still apply. In triploid *Drosophila*, nuclei and cells, organs and individuals are all larger than in the diploid. But in Amphibia, although the nuclei and cells may be proportionately

larger, the individuals are scarcely increased in size at all. The larger animals, which most need to do so, regulate their size, subordinating the cell to the individual, to a degree unknown in the plant[1]. For this reason we find in animals mosaics, and even regulated combinations of diploid and polyploid tissues as successful and important as are the chimæras in plants.

There is thus no physiological difficulty about the origin of new polyploid races in either plants or animals. For both, the difficulties lie in the mechanism of meiosis, and its consequences in germ cell formation. The situation is best known in plants. A tetraploid derived from a true breeding diploid has four identical sets of chromosomes which form groups of four at meiosis. These segregate irregularly, three-to-one as well as two-to-two, and the result is the formation of unbalanced and partly inviable progeny, in other words, infertility. Only when a sterile diploid, a hybrid with two dissimilar sets of chromosomes, *AA′*, *BB′* and so on, doubles its number, do the chromosomes regularly associate in pairs *A*—*A*, *A′*—*A′* and so on, in the tetraploid. Doubling in a hybrid diploid thus restores fertility, instead of impairing it: it gives us a pure-breeding hybrid tetraploid which behaves like an ordinary diploid. New polyploid species of plants are continually arising in this way, *Raphano-Brassica* in experiment and *Spartina townsendii* in Nature, *Triticale* in agriculture and *Aesculus carnea* in the garden[2].

Obstacles to Polyploidy

When abundant polyploids had been found in plants, the question arose of why polyploidy was rarer in animals than in plants. Muller, broaching this question, suggested that an obstacle lay in the disturbance to be expected in the sex-determination of bisexual animals[3]. Disturbance might arise, in the first place, from the failure of the pairing and segregation of *X* and *Y* chromosomes. Also, in the second place, it might arise from the unsuitable balance between the sex chromosomes and the three or four sets of autosomes. New types of balance lead to sterility of the heterozygous sex in *Drosophila* and they might be expected to do so elsewhere.

Later knowledge has largely borne out Muller's expectation. Polyploidy is infrequent in bisexual, although it is probably not infrequent in hermaphrodite, animals; and it is certainly widespread wherever parthenogenesis has been superimposed on a bisexual system. This has happened in nearly all those groups of invertebrates, the most recent being the earthworms, where the question has been studied[4]. In animals as in plants it is indeed by polyploidy that we can trace the evolutionary sequence. We can say that triploidy determined the origin of a parthenogenetic race or species, since the fertilization of a diploid egg by a haploid sperm or pollen nucleus was the first as well as the last genetic event in its history[5].

The breeding of polyploid salamanders also partly bears out Muller's view. Humphrey and Fankhauser have succeeded in raising four generations of polyploids; but they have done so only by crossing polyploid females with diploid males[6]. We have to notice, however, that it is the males, the homozygous sex in this group, which are sterile as tetraploids. How are we to account for this?

Hitherto, hybrids and polyploids have been almost too easy to make in the newts and salamanders. For the analysis of fertility, however, in their polyploid forms we need studies of the same character as those in polyploid plants. We need a comparison of fertilities of diploids and polyploids in pure forms and in hybrids; and they must be precisely first crosses and not later derivatives. These results must be compared with chromosome behaviour at meiosis at least in the male.

So far as we can tell, then, we may say that the sterility of the salamanders seems to be as much that of the non-hybrid tetraploid known in the plant as of the sexually unbalanced type expected in the animal. The limited fertility of the females may itself be helped in these salamanders by a hybrid origin.

Sex-determining Systems

Sex determination may not, therefore, offer the obstacle to polyploidy in animals that we had thought. Nor, indeed, from what we now know of sex determination in animals does it seem likely that the balance system of determination known in *Drosophila* is universal. Rather it is at the end of an evolutionary sequence which arises from what Muller has described as a mere trigger mechanism[5]. For example, the classical animal of the cytologist, *Ascaris megalocephala*, which begins from a basic chromosome number of one, exists in diploid and tetraploid races in Europe and America. These may well be mutually convertible, and they certainly have given rise to hexaploid and octoploid forms which, I understand from Prof. Goldschmidt, exist as races infesting the horses of Mongolia. Since *Ascaris* is differentiated into male and female animals, the differentiation in these polyploids must depend on a trigger rather than a balance.

In the Amphibia such a rudimentary trigger system of sex-determination seems to be general. No differentiated sex chromosomes are to be seen; and in different groups, even in related species, the homozygous–heterozygous relationship may be reversed as between the two sexes, just as it has been in the separate evolution of birds and mammals.

Instability is now seen to be characteristic of many sex-determining mechanisms. The evidence in the mammals is both cytological and genetical. Chains of three sex chromosomes in the marsupial *Potorous tridactylus*[7], and giant sex chromosomes in the vole *Microtus agrestis*[8], both indicate an incorporation of autosomes in the segregating system which determines sex. This means elaboration. The opposite process of degradation, the replacement of a balance by a trigger, is more difficult. For this a new sex-determining segregation must be set up as a single gene-difference between a pair of *X*'s or a pair of autosomes.

A model of such a transformation has indeed been described in man himself (as also, indeed, in *Drosophila*). The Pettersson–Bonnier gene in the *X* chromosome of man converts an *X Y* individual into an apparent or spurious woman[9]. The model is imperfect, since the result is sterile and it arises in the heterozygous sex, merely producing a redundant heterozygosity. But it shows how a new trigger could be brought into action even in our own species.

It is, indeed, above all in the mammals, with their highly developed endocrine systems, that the trigger mechanism may fail to develop into a full balance of the kind realized in *Drosophila*. In this case an obstacle to polyploidy would be removed. Both triploids and tetraploids of the heterozygous sex might be fertile, as they are in the salamander.

Where sex chromosomes are differentiated as in the mammals, another possible difficulty is removed. The sex chromosomes pair only in their short pairing segments and rarely, therefore, form more than one chiasma. For them, therefore, multiple associations are more difficult than for the autosomes. In a tetraploid mammal, association at meiosis will be more regularly in pairs for the *X* and *Y* chromosomes than for the autosomes. This regularity will be increased, as in polyploid plants, by any hybridity of the diploid or tetraploid from which a new type arises. There will be *X*—*Y* and *X′*—*Y′* pairs in the heterozygous sex from which all the usual combinations can be derived.

Polyploid Mammals

The sex-determining mechanism does not, therefore, exclude the possibility of tetraploidy in the mammals, especially tetraploidy arising from hybridization. In this regard certain new observations are of great interest. Fischberg and Beatty have found polyploids, including both triploids and tetraploids, among embryos of the mouse. They are more frequent after crossing, rising to more than 3 per cent spontaneously[10]; and they can be induced by heat treatment of the egg before implantation in as many as 20 per cent[11]. Do such embryos ever reach maturity?

For evidence we must turn to observations of chromosome numbers in wild species of mammals. Here we are faced with a different kind of problem. In all groups of vertebrates there have been doubtful indications of polyploid species. They have been doubtful owing to the sporadic distribution of chromosome studies and the uncertainty of the results. Our present knowledge of the vertebrates, it must be understood, corresponds in proportion and precision with what was known of the flowering plants thirty years ago. After that time a rapid improvement took place in plant technique which changed the face of the subject: the new treatments were easier and their results were more accurate.

The same advance is now taking place in the study of vertebrate chromosomes. Only a few years have passed since La Cour, in showing the part played by nucleic acid supply in the normal and abnormal differentiation of blood precursors in man, displayed the chromosome complement satisfactorily for the first time[12]. Now, from tissue cultures of the human embryo, Hsu has been able to obtain pictures of the chromosome complement such as have rarely been seen in the past outside the flowering plants[13].

The first important result of the new methods has been to show that polyploid species of mammals exist; the second to suggest that they are of hybrid origin. For some time chromosome numbers of 22 and 44 have been claimed for species of hamster. But the possibility of polyploidy has been mentioned by Matthey only to be rejected (doubtless for the theoretical reasons we have been discussing)[14]. Sachs, after confirming the simple doubling of number, has now given the evidence in full. He has shown that form, distribution and history all support the assumption of a recent tetraploid origin for the golden hamster. They indicate its origin as a hybrid in the Caucasian region, where two geologically older species, its presumed parents, overlap[9].

The evolution of the hamsters may be represented as follows:

Cricetus cricetus (Europe eastwards) 22 chromosomes × *Cricetulus griseus* (China westwards) 22 chromosomes

↓

Mesocricetus auratus Syrian or golden hamster 44 chromosomes

Here we see the genesis and history of a species diagrammatically revealed, much as it was revealed twenty-five years ago in the now classical instances of polyploid plants of recent origin.

We can seldom expect to find the records so neatly preserved. Species often die, and chromosomes are often broken. What we shall usually find is the bald fact of an approximate two-to-one ratio of chromosome numbers. Such a ratio seems to connect the only two of the innumerable races of African and Indian gerbils which have so far been described, both of them this year[8,15]:

Tatera brantsii dracо : $2n = 34$ (Tobias)
Tatera indica ceylonica : $2n = 72$ (Sachs)

How could a polyploid species arise in the way the golden hamster seems to have done? It might come about, as it commonly does in plants, through the frequent production of infertile diploid hybrids whose sole means of making effective germ cells would be through non-reduction, the failure of the first or second meiotic division. The eggs would then all have *XX* chromosomes, the sperm *XX*, *XY* and *YY*. If the last of these gave less fertile zygotes, the others, *XXXX* and *XXXY*, might well be efficient enough to start a new species with sexes in equal numbers.

An alternative possibility is favoured by the mouse experiments. It is that the new tetraploids arose at fertilization in the original crossing of the two species through non-reduction in both parental species. There are, however, as the salamander experiments have shown, only too many possibilities for the origin and breeding of polyploids. When we recall that the chromosome numbers are accurately known for much less than one per cent of all the species of mammals, it becomes clear that polyploidy may have been concerned closely or remotely in the history of any or all mammalian groups.

Origin of Man

Now, among the orders of mammals, the primates are almost the least explored in their chromosome history. At the present moment the chromosome number is known only for one or two species of monkeys apart from ourselves: and those observations, although no doubt accurate, were made nearly thirty years ago[16,17]. Where cytologists abound it seems that monkeys are scarce. Moreover, the owners of collections of living animals maintained for exhibition to the public, or for scientific purposes, are not disposed to lend their precious charges for investigation; or, at least, not until the animals are dead and their chromosomes no longer decipherable. It might well happen therefore that, after the last gorillas, chimpanzees and orang-utans had all expired in their cages, we still should not know their chromosome numbers. We should not know whether, for example, one or more of them had had half or twice our own outfit of chromosomes. Or whether we had differed only by a small amount of fragmentation and the loss or gain of a few inconvenient genes.

Great institutions have been devoted to collecting and preserving, describing and naming, the bony

fragments of our ancestors and relatives, and great bodies of literature have been brought forth by their labours. Rightly so. Yet at the cost of a few hundred cells, a few drops of blood, a few moments of discomfort to the animals, and a few hours of work to a cytologist, the genetic record of human evolution could be laid bare. It would, perhaps, be worth while.

[1] Fankhauser, G. *Quart. Rev. Biol.*, **20**, 20 (1945).
[2] Darlington, C. D., *Nature*, **124**, 62, 98 (1929).
[3] Muller, H. J., *Amer. Nat.*, **59**, 346 (1925).
[4] Muldal, S., *Heredity*, **6**, 55 (1952).
[5] Darlington, C. D., "The Evolution of Genetic Systems" (Univ. Press, Cambridge, 1939).
[6] Humphrey, R. R., and Fankhauser, G., *J. Hered.*, **40**, 7 (1949).
[7] Sharman, G. B., and Barber, H. N., *Heredity*, **6**, 345 (1952).
[8] Sachs, L., *Heredity*, **6**, 357 (1952).
[9] Pettersson, G., and Bonnier, G., *Hereditas*, **23**, 49 (1937).
[10] Beatty, R. A., and Fischberg, M., *J. Genet.*, **50**, 471 (1952).
[11] Fischberg, M., and Beatty, R. A., *Evolution*, **6**, 316 (1952).
[12] La Cour, L. F., *Proc. Roy. Soc. Edin.*, B, **62**, 73 (1944).
[13] Hsu, T. C., *J. Hered.*, **43**, 167 (1952).
[14] Matthey, R., *Chromosoma*, **5**, 113 (1952).
[15] Tobias, P. V., *S. Afr. J. Sci.*, **48**, 366 (1952).
[16] Painter, T. S., *J. Exp. Zool.*, **39**, 433 (1924).
[17] Painter, T. S., *Amer. Nat.*, **59**, 385 (1925).

THE LOGIC OF EXPERIMENT

By Dr. J. BRONOWSKI
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EVERYTHING in our experience is particular; and science seeks to link it by general laws. How does the observer pass from the particular phenomena to the laws for which they are thought to provide evidence? This is the classical problem of induction, as a human habit. We are here concerned, however, only with that part of it which is formalized in scientific method.

A law, in this meaning, is a statement from which phenomena can be derived by deductive steps. The aim of induction in science is therefore to propose a system of laws from which everything in our experience will be seen to follow by strict deduction.

The Axiomatic Model

Ideally, such a system is put in an axiomatic form. That is, there is postulated a set of primitive entities, of whatever kind—they may be reflexes, or genes, or enzymes, or mass and force (for they need not be observable). A system of axioms then lays down how these entities behave and may be combined; Mendel's rules or Newton's laws of motion are examples. With this goes a dictionary to say what conjunctions of the fundamental entities can be observed, and what these observable appearances are. The model is now ready to be set going.

The model proceeds by steps, and in a natural science these steps take place in time. Some of the axioms therefore must say how the postulated entities move or change in time. These are, broadly, the causal laws, which describe sequence or consequence.

Experiments in Time

There can, of course, be no assurance that these sequences will follow in the future the same laws that they have followed in the past. Nature might at any instant break with herself. This remark is a valid warning against prediction and other extrapolations; but it does not, as has been thought, bear upon the process of induction which underlies them. Induction remains the process by which science seeks to trace an order in what has been experienced. At any instant (even at the instant after an experiment) this search can involve only the past record.

When an experiment repeats what was done before, it adds to this record. It does so, first, to give a narrower estimate of error. But even if experiments were free from error, the repetition would not be trivial. For it serves to scrutinize, from time to time, the way in which time has been written into the axioms. For example, we go on measuring the speed of light for both reasons, for we are by no means sure that it is not growing with time.

'Probability' of Laws

To assert that a law is true is to claim that, ideally, all the phenomena which can be deduced from it could be verified. Even when we confine ourselves to the past record, this is a claim that cannot be proved; it can at best be tested. For any record can only be a sample, even of the history which it records: it is the nature of experience that it only samples the universe. It is therefore pertinent to ask of a law or model: How probable is it that the configurations which it generates would have matched the universe at all points, because they match it at so many sample points?

The question is commonly put in this form; but it is not happy, for the phrase 'how probable' cannot make sense. The probability of hypotheses is a pointless inquiry. There is always an infinity of distributions from which the finite set of sample points might have been drawn; and there can always be constructed an infinity of hypotheses or models which will generate the same finite record. In any absolute sense, the probability that one hypothesis is right is therefore always zero.

This difficulty is not met by making the sample larger. Experiments are, of course, designed (this is their third function) to test the fit of the axiomatic model at new sample points. If they fail, the model is rejected; but their success, even when it is as spectacular as the discovery of Neptune, can never make the model probable in itself. It can, in fact, only make it more probable than another specified model; or, to put the matter so that it really has a defensible meaning, it can give reasons for preferring one model to another.

Critical Evidence

Such an experiment, when it is well designed, is a challenge to Nature to opt for one of two replies. The great experiments of history are charged with this critical sense: the apocryphal experiment from the tower of Pisa which Galileo was long thought to have made, the interference of light, the work of Pasteur and that of Sherrington, the Michelson–Morley experiment, the charting of black-body radiation, the eclipse of 1919, the search for Yukawa's meson. In an absolute sense, at least some of these experimenters were mistaken, for they thought themselves to have established laws, which have since in their turn been ousted by others. But in the sense that matters, their experiments were as decisive as the discovery in a crossword that 'bezique' crosses 'syzygy' at the right point.

It has long been seen that some sciences, such as palæontology, depend on this interlocking of evidence. By contrast, it has been thought (for example, by Collingwood) that the experimental sciences arrive at

laws by a simpler accumulation of evidence. This distinction is false. Laws must be guessed by induction; they must be fitted together into an axiomatic model; and the model can only be tested by such critical devices.

The point is crucial; and it leads us to ask: How, in fact, does the scientist invent the nexus of primitive entities and their relations which make his model? The axioms of Euclid do not raise this question, because plainly they are simple experiences in geometry, and this is why they were long thought to be self-evident. But the entities which underlie an axiomatic description of Nature are not at all immediate to the senses. How does science come to isolate them?

Experiments as Messages

Leibniz gives the clue to this when he says that the scientist must read the cryptogram in Nature. His hint has been neglected; but then, so has the whole fundamental problem.

Take some commonplace from the chemistry book, the simpler the better: say, the action of sulphuric acid on common salt. This reaction was known to Dr. Glauber in the seventeenth century. From that time, apothecaries knew what substances are involved, and more and more other reactions in which they take part. All these reactions were in a sense messages, that is, they had a systematic content; but chemists failed to read them, and chemistry remained incoherent, until their code was broken down. In effect, modern chemistry begins when Glauber's reaction could be written as

$$2\,NaCl + H_2SO_4 \rightarrow Na_2SO_4 + 2\,HCl.$$

This and the formulæ like it trace an order in the chemical actions by showing that they are all assembled from one set of code letters or elements.

The code does not stop there. It prompts the chemist to ask why S is so often coupled with O_4, and why the letter H moves about in so many of these messages. This is the familiar step in decoding which counts the frequencies of letters and of groups, and here it at once leads to the theory of valencies. From it we pass to physical theories, which seek a still more compact structure within the alphabet of ninety or so elements. The messages of physics can, in fact, be broken down, by these steps, first to electrons and unidentified nuclei, and then to a three-symbol Morse code of electrons, neutrons and protons.

Code and Meaning

In this procedure, Nature is conceived as an assembly of processes (and not of objects or events). The sentences which describe these processes are thought to be a set of code messages. To trace the laws within the processes is then systematically to break down the code into its constituent symbols and their laws of arrangement. This is the most powerful form of the axiomatic method, for it recognizes that we do not analyse experiments but the sentences which record them.

This procedure, however, as yet has no criterion for preferring one axiomatic model to another. The choice between two ways of decoding the sentences, and the wish to pass from a code of ninety-odd symbols to one of three symbols, must be governed by a rational demand. This requirement is that the code shall make the content of information in the record as large as possible. In this context, information and meaning are identical; so that this is the demand that *the code shall make Nature as meaningful as possible.*

By way of example, consider two models each of which can account for the same set of experiments. The experiments are read as messages on the symbols and axioms of the two models; they therefore have in each case a content of information made up of sums

$$-\sum_i p_i \log p_i,$$

where the p's are the probabilities that the symbols occur in their places by chance. The demand for the larger content of information therefore prefers the model in which the symbols have more free choices for their occurrence or behaviour. Succinctly, we are to prefer the less restrictive model; or, as Ockham put it, we are not to multiply hypotheses.

Even the messages of Nature, of course, do not reach us without noise. This background noise is provided by the experimental errors and ultimately by the coarseness of all observation. To this, Nature might have added a random process of her own, with no known law of distribution. But if so, we have not detected it. We set about the task of decoding on the assumption that nothing in the processes of Nature is meaningless.

Direction of the Message

A message has only one dimension, and most scientific constructs have several. But since the message transcribes a process or experiment, plainly it singles out the dimension of time. Objects, events and structures are to be pictured within the code groups, where they can have their own function spaces. The direction of the message is the direction of time.

But, of course, a code message carries no mark of direction, and it might read forward or backward. Even a book of messages, or the whole record of the past, might be decoded in either direction; and its meaning would not be essentially different, with one exception. The exception is that we should not know which way time is running. This is an odd and final use of experiment: that we have to add one experiment of our own to the record, in order to fix the direction of time as we experience it.

OBITUARIES

Sir William Dampier, F.R.S.

Sir William Dampier was born in 1867 and named William Cecil Dampier Whetham. His early work was published under that name; but later he changed his surname to that of his mother's family. His father and grandfather were prominent citizens of London, the latter being its Lord Mayor in 1878; but his own most vital interest lay in the country rather than the town. After taking his degree in Cambridge in 1889, he went to work in the Cavendish Laboratory under the inspiration of J. J. Thomson. The best-known result of his early work is his experimental proof that when liquids flow through tubes there is no slipping at the liquid–solid interface. Later he studied the motion of ions in liquids and developed methods for measuring ionic velocity which have since been used by others. With E. H. Griffiths he made accurate measurements of the conductivity and depression of freezing points of

dilute solutions and showed that their results were in agreement with the ionic theory which Arrhenius had recently put forward. As a result of these studies he published in 1902 his book "The Theory of Solution", which was for a time the standard text-book on the subject.

In 1891 Dampier was elected to the fellowship at Trinity College, Cambridge, which he retained until the end of his life. After serving for some years as a College lecturer, he accepted the heavy duties of a College tutorship. In this office he showed a capacity for human sympathy which his many pupils gratefully remember; but his duties took up so much of his time that he had to drop his laboratory work. His mind, however, was very active. During this period he published books on eugenics and was collecting material for his "History of Science" (1929).

Meanwhile, with his love of the country and country pursuits, Dampier could not be satisfied with life spent entirely in Cambridge. He and his wife bought an estate in Devonshire, and problems connected with agricultural economics soon forced themselves on his attention. In 1917 he inherited a small family estate. At that time he was working part-time with Sir Thomas Middleton at the Food Production Department of the Ministry of Agriculture. He characteristically decided to put his agricultural ideas to the test by taking two farms near his estate and operating them through a manager. The scarcity of cheese during the First World War directed his attention to this product, and he set up a small cheese factory in connexion with his farms. Here the problem of using the surplus whey led him to experiments in the production of lactose, which eventually developed into a process used on a commercial scale.

The falling prices from 1920 onwards focused Dampier's attention on the relationship between money, prices and agricultural profits. He published his opinions on these subjects in the *Economic Journal* (1925) and in a book, "Politics and the Land" (1927).

The interest aroused by these publications and the reputation for sound judgment which Dampier had acquired in several forms of public service led to his being consulted by the Government on many problems of agricultural policy. Of these none was more important than those which led to the formation of the Agricultural Research Council. After the First World War, when it became clear that the Government would have to spend large sums in supporting scientific and medical research, the Department of Scientific and Industrial Research and the Medical Research Council were set up to encourage and regulate government expenditure and activity in these fields. No such body existed for agricultural science; but a number of laboratories devoted to agricultural research were being largely supported through public funds. Since these independent bodies were in some cases absorbing increasingly large grants, it became clear to the authorities that a body analogous to the Department of Scientific and Industrial Research or the Medical Research Council would have to be set up for agriculture. Dampier's tact and experience were of great value during the delicate negotiations which were necessary to bring the existing independent bodies into a state of mind favourable for setting up an Agricultural Research Council which would regulate their grants. Dampier became the secretary to the Council, and guided it in the difficult early stages until it became firmly established. He also took great interest in rural community councils.

Dampier was elected to the Royal Society in 1901, was knighted in 1931 and awarded the Gold Medal of the Royal Agricultural Society in 1936. He married Catherine Holt in 1897 and had five daughters. His loss will be deeply felt in Trinity College, to which he was so devoted and gave such good service.

G. I. Taylor

Prof. L. B. Smyth

Louis Bouvier Smyth was born in Dublin in 1883 and died there on July 11, 1952. His father was Mr. Isaac Smyth of Dublin; his mother was French. He received his school education at Wesley College, Dublin, and entered Trinity College in 1902. He graduated in 1906, obtaining senior moderatorship in natural science with a large gold medal, awarded for first place on exceptionally high marks. In those days candidates took botany, geology and zoology, equal weight being assigned to each course during the four years; but for the degree a special course also had to be taken in one subject. Smyth took botany and was appointed as assistant to Prof. H. H. Dixon during the period when the present School of Botany was being built and the department organized. This happy collaboration continued for three years. He then accepted a post as naturalist in the Fisheries Branch of the Department of Agriculture and took part in several cruises to study, in particular, the phytoplankton. After a year there he was invited by Prof. John Joly to join his staff, and from 1911 until his death he continued in the Iveagh Geological Laboratory at Trinity College, Dublin. In 1911 also he married, very happily. He is survived by his widow.

Joly sent Smyth to work in Oxford under the late Dr. Arthur Vaughan, the leading English palæontologist of that period, and, on his return to Dublin, Smyth was appointed lecturer in palæontology. Then for more than twenty years he did all the exclusively honours teaching in the Geological Department in mineralogy, petrology, palæontology and geological map-reading. Sometimes also he had to lecture as Joly's deputy, and in six consecutive years he had the Senior Engineering Class on ore deposits. From 1931 until 1934 he occupied also the newly made post of lecturer in geography.

But Smyth's influence in Trinity College, Dublin, extended far beyond the geological laboratories. He joined the O.T.C. when it was first started, and was commissioned. He was in the Territorial Forces (Unattached List) in January 1915 and was promoted lieutenant 1916; but a disabling affliction denied him his wish of going on active service. The value of his military work may be realized on looking at the T.C.D. War List (1922); the total trained by the Corps was 1,490, with some 3,000 members of the University serving, and more than 460 names on the walls of the Hall of Honour. On committees too his quiet business-like manner and precision were of much value; most notable was his service as secretary of the University Council, and on the Board of Trinity College in his last years.

His first published work (1911) was with Joly, on the radium emanation in the soil. The rest were almost all in his sole name and appeared mainly in the *Scientific Proceedings of the Royal Dublin Society*, the *Proceedings of the Royal Irish Academy*, the *Geological Magazine* and the *Quarterly Journal of the*

Geological Society of London. In these the patient examination of the strata and the marshalling of the palæontological evidence linked up the geology of North Wales and the Irish coast. The first of the series dealt with the faunal zones of the Rush–Skerries Carboniferous Section, Co. Dublin, and further papers considered the strata at Malahide and at Ballycastle, Co. Antrim. The fine paper on the geology of Great Orme's Head (1925) led to the award of the Sc.D. degree. The Irish Academy published a similar contribution on the Carboniferous Rocks of Hook Head, Co. Wexford (1930). His papers gave detailed descriptions of fossils, notably of corals.

In 1934 Smyth succeeded Joly in the University chair of geology, which he occupied until his death. He devoted himself, unremittingly, to his teaching, and to the improvement of the Geological Museum and Department. He was never happier than when taking his students and overseas colleagues on geological expeditions—and few university cities have more varied geological interest close at hand than has Dublin. After a gap, occasioned by his teaching duties and illnesses, came "The Carboniferous System of North County Dublin" (Geol. Soc., 1950) and "A Visean Cephalopod Fauna in the Rush Slates" (Roy. Irish Acad., 1951). A clear lecturer, a sympathetic teacher, loyally devoted to his University, a true friend—there are many who mourn his loss.

W. R. G. Atkins

Mr. C. E. N. Bromehead

Cyril Edward Nowill Bromehead, formerly of the Geological Survey, died on December 4. He was born at York on January 8, 1885, and was educated at Marlborough and at Merton College, Oxford. He joined the Geological Survey of Great Britain in 1909 and was assigned as his first major task the 6-inch survey of a large part of the London area. With Henry Dewey he devised the present nomenclature of the gravel-terraces of the Thames Valley, and he became an authority on the geology and early history of London and particularly on the buried tributaries of the Thames such as the Fleet and Ty Bourne.

In the First World War he served in Flanders and was severely wounded. He returned to the Geological Survey in time to take part in explorations in Derbyshire which led in 1919 to the drilling of Britain's first oil-well at Hardstoft.

In 1922 he was appointed district geologist in charge of Yorkshire. Employing techniques of stratigraphical palæontology then being devised by W. S. Bisat, Sir Arthur Trueman and W. B. Wright, he and his staff became experts on the Upper Carboniferous rocks. In fifteen years his unit made a detailed revision of most of the coalfield and its borders—an area of nearly 1,000 square miles—and sent to the press the relevant maps and memoirs as well as a new edition of the memoir on the "Concealed Coalfield of Yorkshire and Nottinghamshire". These publications have proved invaluable in subsequent developments of the coalfield.

In 1935 Bromehead took charge of geological work in Southern England, where mapping was proceeding in Kent. For much of the next ten years, however, his duties were connected with the Second World War, and throughout this time his knowledge and experience were always at his colleagues' service. He relinquished some of his responsibilities in 1945 and retired in 1949.

During this last period his interest in the origins of geology and related arts (he was a founder-member of the Society for History of Science) was revealed in two presidential addresses to the Geologists' Association on the early history of practical geology and mining in Britain, and in papers on antiquarian subjects—'eagle-stones', loadstones, 'murrhine', early water-supply and museums—in which a high order of classical scholarship was delightfully blended with geology. He also wrote on oil, reservoir-dams and fluorosis.

Profoundly influenced in his youth by what was then known as the 'Oxford Movement', Bromehead practised religion with characteristic thoroughness. He is remembered with affection by the many who experienced his kindliness and culture, his wisdom and, not least, his firmness in moments of crisis.

Wilfrid Edwards

Mr. R. S. Styles and Mr. F. W. Campbell

Ronald Stephen Styles and Frederick William Campbell, who were attached to the Division of Radiophysics of the Commonwealth Scientific and Industrial Research Organization, Australia, were killed in an aircraft accident near Sydney on October 27 while engaged on research in cloud physics and natural rain formation.

Styles and Campbell were on a routine flight in an R.A.A.F. Dakota fitted for cloud 'probing' using microwave radar and special instruments designed in the Division of Radiophysics for observing cloud temperature, liquid-water content and cloud droplet spectra. The aircraft had been investigating clouds over the sea and reported that it was descending from 6,000 ft. to 2,000 ft. through low cloud and heavy rain preparatory to returning to base. It failed to report at the next check-point, and an intensive emergency search was immediately organized. Oil, wreckage and a half-inflated rubber dinghy were found a short distance out to sea, and some items recovered were identified as belonging to personnel on the aircraft; all on board, including an R.A.A.F. crew of four, were killed.

Mr. Styles was born in Sydney, New South Wales, in 1926. At the University of Sydney he took a course combining physics and electrical engineering. He graduated with the double degree of B.Sc. and B.E. and joined the Radiophysics Division as a research officer in March 1948. His initial work concerned radio aids to aircraft navigation, to which he made valuable contributions. He was then transferred to work on rain and cloud physics, and his obvious ability and enthusiasm soon led to his taking a major part in airborne observations of natural rain. His observations of the development of non-freezing clouds to give rain are of particular interest. He also contributed significantly to the development of instruments in this field and displayed a marked ability for organizing, implementing and analysing results in this difficult field of research. He leaves a widow and an infant son.

Mr. Campbell was born in 1915, at Norseman, Western Australia. After successfully completing a radio course at Perth Technical College in 1934, he spent the pre-war years as a radio engineer in Perth. During the Second World War he served with the Royal Air Force, rising to the rank of squadron leader. He undertook specialized radio and radar courses at Prestwick, Great Malvern and elsewhere,

was mentioned in dispatches for meritorious technical services and was finally senior radar officer to No. 38 Group, R.A.F. After the War he was appointed to the Department of Civil Aviation in Sydney. He joined the staff of the Commonwealth Scientific and Industrial Research Organization in August 1947 as a technical officer, and was an active member of the team carrying out flight trials and experiments on radio aids to navigation. He had a first-class knowledge of aircraft radio equipment. He later joined the Rain and Cloud Physics team and for several years worked in partnership with Mr. Styles. Mr. Campbell was married and had two young children.

The death of these two young men is a tragic loss to Australia. Their work in the field of rain physics was just beginning to bear fruit, and their loss means a serious setback to the research in cloud physics which has progressed so well in Australia.

Dr. E. H. Hunt

Dr. Edmund Henderson Hunt was educated at Harrow and Balliol College, Oxford, where he took a first in physiology under J. B. S. Haldane, and went on to St. Bartholomew's Hospital, London, where he added the F.R.C.S. to his M.Ch.(Oxon.). He then accepted the appointment of chief medical officer to the Nizam's State Railway, Hyderabad, more or less as a temporary measure, but he found his life's work there. Apart from the constant pressure of his medical and surgical work at the Lallaguda Hospital, he developed a large private practice, which took him into all parts of the great city. The wide first-hand knowledge of the country he so gained led him to interest himself in anthropology and archæology. He was a fellow of long standing of the Royal Anthropological Institute, and published the results of important excavations of the Hyderabad urn-burials, and other papers, including a remarkable contribution on black magic, from the clinical point of view. His incomparable photographs of Ellora and Ajanta were widely known and did much to encourage the growing interest in Indian art. He was, also, a collector of Celadon. On retirement, he became interested in scientific bee-keeping, and was chairman of the Farnham Association and a member of the National Honey Show committee. To these activities must be added the many research activities in India, from geology to archæology, which would have been impossible without his helping hand. He was a true colleague to any research worker who approached him, a real friend of India, and an unforgettable personality.

K. de B. Codrington

NEWS and VIEWS

Queen Elizabeth College

The granting of a Royal Charter to Queen Elizabeth College, University of London, marks the beginning of a new phase in the work of what has hitherto been known as King's College of Household and Social Science. Beginning as a department of King's College for Women in 1908, it gradually developed research and teaching in the scientific aspects of household and social work, until in 1920 there was introduced the first degree in these subjects—B.Sc. (Household and Social Science). By 1928, the department became an independent school in the University of London under the title of King's College of Household and Social Science. It played a prominent part in the development of dietetics as a specialized study, and began, in 1933, the first courses leading to a diploma in dietetics. Now, with its Royal Charter and its new name, Queen Elizabeth College (after Queen Elizabeth, the Queen Mother) is breaking new ground. From October 1953 it will be training men and women undergraduates in the science of nutrition, leading to the new degree of B.Sc. (Nutrition). So far as we know, there is no other university in Britain which gives an undergraduate course for a first degree in this subject. A brief account of this degree and of the new degree of B.Sc. (Household Science) was given in *Nature* of August 9, 1952, p. 226.

'Krilium'

In December 1951 publicity was given to the discovery of a new way of improving soil structure by the use of certain synthetic polyelectrolytes produced by Monsanto Chemicals, Ltd., under the trade name 'Krilium' (see *Nature*, **171**, 7; 1953). Other conditioners were afterwards announced by other manufacturers. During 1952 experiments have been made with 'Krilium' by several agricultural research institutes in Britain and by the National Agricultural Advisory Service under the auspices of the Agricultural Research Council. The substance used was supplied by Monsanto Chemicals, Ltd., as 'Krilium' (*CRD.* 189) and described as a sodium salt of polyacrylic acid. This was the earliest available soil conditioner and in its original form proved somewhat difficult to incorporate in moist British soils. The results of the 1952 experiments have now been examined. They were not expected to be more than preliminary, and no definite conclusions, therefore, can be drawn at this stage of investigation. The initial findings can be summarized as follows. (1) Improvement in structure after treatment was apparent in many of the soils tested. (2) The uptake by plants of major and minor nutrients was not adversely affected. (3) The activity of soil micro-organisms was normal. (4) No conclusive evidence was obtained that the application of 'Krilium' caused any significant increases in crop yields of field or of glasshouse crops, though in certain cases increased yields were recorded. Much more experimental evidence on the best method of incorporation, degree of aggregation and persistence of structure of treated soils, and the relation of these to crop yields is required before any definite conclusion can be reached. Towards the end of the year Monsanto Chemicals, Ltd., made available a new soil conditioner, described as a calcium salt of vinyl acetate–maleic acid copolymer. This was found to be more easily incorporated in soil and is stated to have better soil aggregating properties than *CRD.* 189. Experiments will be continued in 1953 and the results, when complete, will be published in the usual reports and journals.

Associate Directorship of the U.S. National Science Foundation

The new post of associate director of the United States National Science Foundation has been filled

by Dr. Paul E. Klopsteg, at present the assistant director for mathematical, physical and engineering sciences of the Foundation, and his place is being taken by Dr. Raymond J. Seeger, the programme director for physical sciences in the Foundation. In his new appointment, Dr. Klopsteg will be responsible for assisting the director and the deputy director of the Foundation in following closely the development of relationships with universities and with other Federal agencies; he will also handle special assignments of importance to the scientific programmes of the Foundation. Dr. Klopsteg is a graduate of the University of Minnesota, and in 1916 he gained there his Ph.D. in physics. His professional career has been devoted to the administration of research, and before the Second World War he was president of the Central Scientific Co. During the War he served with the Office of Scientific Research and Development as chief of Division 17, Physics and Special Devices, of the National Defense Research Committee, which developed important equipment and devices for war-time use. Later he was assistant chief of the Office of Field Service, which organized and directed the assignment of scientific consultants to the various theatres of war, and in this capacity he served in Australia and New Guinea as chief of the Research Division, General Headquarters, Southwest Pacific. Dr. Klopsteg has been chairman of the board of governors of the Argonne National Laboratory and is chairman of the Committee on Artificial Limbs of the National Research Council. He is at present on leave of absence from his post as professor of applied science and director of research of the Northwestern Technological Institute, Evanston, Ill.

International Association for the Exchange of Students for Technical Experience

THE fifth annual report of the International Association for the Exchange of Students for Technical Experience (pp. 56; from the secretary, J. Newby, at the Imperial College of Science and Technology, London, S.W.7) records continued progress both numerically and geographically: 3,493 students were sent abroad during 1952, an increase of 1,060 over the previous year. Yugoslavia joined the Association in January 1952, and the Saar and Turkey were represented at the conference of organizers. One large company with international interests selected in 1952 twelve undergraduate students for nomination to its overseas connexions and received twelve students in Great Britain selected by its overseas counterpart. Places available abroad for students of business administration and commerce increased to 112 as compared with 35 in 1951. More students were accepted than were sent in the following countries (numbers shown in brackets): Sweden (547), Great Britain (114), United States (47), Switzerland (37) and Spain (2). Of countries sending more students than they accept, Austria (161), Germany (148), Netherlands (113), Finland (94), Denmark (93) and France (51) show the largest excesses.

Since the establishment of the Association in 1948, some 1,440 industrial and other organizations have received foreign students under the scheme; it is estimated that during the summer of 1952 international industry and commerce contributed more than £161,000 to the Association's programme. The report includes an analysis of industries participating in the exchange and also of the subjects which participating students were studying. A list of institutions and firms taking part in the scheme is included under each country, and a supplement gives further details of exchanges in which Great Britain participated in 1952, when 488 students were sent abroad and 602 foreign students were received and placed. Travelling arrangements appear to require improvement, but relations between the students and other workers were entirely satisfactory, and an interim evaluation of the reports received on British students indicates that 1952 has been the best year both in the numbers sent abroad and in the service given.

International Trade in Agricultural Machinery

TECHNICALLY there is scope for much greater use of agricultural machinery, according to a report issued by the Commonwealth Economic Committee, "A Survey of the Trade in Agricultural Machinery" (No. 36; pp. 174. London: H.M.S.O., 1952. 7*s.* 6*d.*). Rises in the prices of agricultural machinery have been considerably less than those of the principal agricultural commodities, while the urge for greater agricultural production together with widespread increases in the cost of labour should combine to increase the demand for mechanization. Figures relating to world exports of agricultural machinery show that values rose from £25 million in 1938 to £300 million in 1951. In the post-war period, the United Kingdom has become the second largest manufacturer of tractors in the world, although she is still greatly outdistanced by the United States, where the production is four and a half times as great. The report shows that recent developments have been directed towards reducing manual labour on farms, or mechanizing processes which call for seasonal peaks in labour. To reduce labour costs, balers, loaders and handling gear, electric fences and dung spreaders are being increasingly used, while to decrease the need for casual labour, root harvesters in Europe, sugar-cane harvesters in Australia and cotton harvesters in the United States are being adopted. An important aspect of development has been the adaptation of standard implements to new tasks as, for example, the application of rotary cultivators and combine harvesters to crops of irrigated rice in India.

Scientific Methods in the National Gallery Laboratory

AN article on "Scientific Method and the Art Gallery", by Mr. F. I. G. Rawlins and Dr. A. E. Werner, of the National Gallery Laboratory, London, has been published in *Science Progress* (90, No. 160), in which the authors review developments at the Laboratory since 1939 and show how the application of science has aided the care of pictures. Studies in the effects of temperature and humidity changes and the introduction of air-conditioning are recorded. Recent work in the use of X-rays, ultra-violet and infra-red rays in the examination of works of art is discussed, and some details are given of chemical and physical techniques now used in the treatment of pictures.

Studies in Conservation: Journal of the International Institute for the Conservation of Museum Objects

THE appearance of a new periodical is in these days an event of prime importance, and especially if that periodical may interest comparatively few

members of the public, because then the venture is even more hazardous. The first number has now been published of *Studies in Conservation* (1, No. 1; October 1952. Pp. 48. London and Edinburgh: Thomas Nelson and Sons, Ltd; about 2 Nos. a year, 21*s.* net a year), which is the journal of the International Institute for the Conservation of Museum Objects, and it raises this very issue, for, although the public to which the journal is addressed is small, it is very important inasmuch as the preservation of the world's art treasures depends on the standards maintained in practice by a relatively small number of professional conservators. When "Technical Studies in the Field of the Fine Arts" discontinued publication, conservators were left without any medium of communication of a strictly comparative type; it is this gap that it is hoped the new journal will fill. The policy adopted and the scope of the work covered by the journal is well expressed in the editor's preface: "Whereas nothing less than the best—and that implies the most meticulous—in the way of scholarship will suffice, there is every reason why studio and laboratory processes should receive equal prominence. Knowledge advances by the mastery of technique . . .". This statement is fully upheld by the contents of this first number, which contains articles written by authorities in their respective subjects covering a wide field; they include an account of a detailed investigation of the Dirk Bouts altar-piece, an interesting X-ray examination of an ancient metal object, and a record of valuable data concerning the hygroscopic behaviour of wood. All the investigations have yielded results that are of great interest to those engaged in the conservation of museum objects. The number closes with reviews of books dealing with the treatment of pictures, metallurgy in antiquity, defects of paint films and the surface chemistry of solids. The editor and publishers are to be congratulated on the production of a most acceptable first number, both on account of the choice of material and the quality of the printing and the reproductions. The journal should appeal not only to those who are directly concerned with the problems of conservation but also to the far wider circle of those who take a general interest in museum objects.

New Spectrophotometer for Visible and Near Infra-red Radiation

A NEW spectrophotometer, the '*SP.* 600', for accurate colorimetric measurements within the visible and near infra-red regions of the spectrum, has been designed by Unicam Instruments (Cambridge), Ltd., of the Arbury Works, Cambridge. With this instrument the analysis of a sample, or comparison with a reference substance, can be speedily carried out. Over the greater part of the spectral range the band-width is about 30 A., and this is sufficiently narrow to reduce to a minimum effects commonly associated with spectral impurity at the selected wave-lengths. The instrument controls are simple to operate and consist of the following: a wave-length dial, calibrated in 10-A. divisions from 3600 to 4500 A. and then in 20, 50 and 100 A. to 10,000 A.; controls for slit width, dark current, transmission or optical density; and a selector switch for a red or blue (for use below 6500 A.) photocell. The light source is a tungsten lamp, and the optical system is a simple Littrow monochromator with glass prism. The photocell output current is amplified. Bias and high-tension voltages are provided by dry batteries housed underneath the spectrophotometer, but lamp and heater supplies must be obtained from an external 12-V. source. The illustrated pamphlet describing the instrument includes a transmission/wave-length graph of Chance *O.N.* 12 didymium glass taken on a standard form of the spectrophotometer, and details of the dimensions and accessories of the instrument.

Educational Grants for Training in Plastics

THE trustees of the Plastics Industry Education Fund have decided as an experiment to allot up to £2,000 over a period of two years for maintenance grants for students attending a new two-year full-time course in plastics at the Borough Polytechnic, London. The course, which is for a minimum of eight students of about sixteen years of age who have taken the General Certificate of Education, will follow the syllabus of the City and Guilds of London Institute, leading to the diploma of the Plastics Institute at the end of the second year. Applications to attend the course should be made to the Principal, Borough Polytechnic, London, S.E.1. The trustees have also decided to allot £2,000 for capital equipment in technical colleges in Great Britain, which will include the Acton Technical College, the College of Technology, Birmingham, the Newton Heath Technical College and the National College of Rubber Technology.

Awards for Technical Articles on Radio

THE Radio Industry Council is continuing its practice of making awards of 25 guineas, up to an average of six a year, for technical articles on radio published during the past year in any public journal. The principal criteria in judging will be the value of an article in making known British achievement in radio and electronics, originality of subject, technical interest and presentation and clarity. Only authors whose salary is not mainly or wholly gained by writing are eligible. They should submit their work (five copies if possible) to the Secretary, Radio Industry Council, 59 Russell Square, London, W.C.1, from whom all further particulars can be obtained.

Research Fellowships at Government Scientific Establishments

FOR several years Ministry of Supply research fellowships, tenable at Harwell and certain other Ministry of Supply establishments, have been offered annually, and now a small number of similar research fellowships is being instituted at other government scientific establishments. A considerable choice of subject will be allowed to research fellows, provided that it falls within the field of work covered by the establishment to which they are attached. The fellowships will be tenable for three years and will carry benefits under the Federated Superannuation System for Universities. Remuneration will depend on individual merit and experience and will be £800–1,000 a year inclusive for senior awards and £500–700 for junior awards. The fellowships will be advertised by the Civil Service Commission as the occasion arises, and advertisements for the first awards should appear within the next few weeks.

Colonial Service: Recent Appointments

THE following appointments in the Colonial Service have recently been announced: B. G. Kinloch (assistant game warden, Uganda), game warden, Uganda; A. F. W. Sheffield (principal agricultural

officer, Nigeria), deputy director of agriculture, Eastern Region, Nigeria; E. H. Probyn (senior assistant conservator of forests, Cyprus), conservator of forests, Tanganyika; P. E. Glover (research officer (botanist), East African Trypanosomiasis and Tsetse Research and Reclamation Organization), chief field geologist, Kenya; T. H. P. Hartley and J. A. Howarth (agricultural survey officers, Gold Coast), principal agricultural survey officers, Gold Coast; F. A. Leeds and D. Westwood (agricultural officers, Gold Coast), senior agricultural officers, Gold Coast; L. Lotringer, J. A. Makinde, S. Z. Moczarski and G. E. Okiy (agricultural superintendents, Nigeria), agricultural officers, Nigeria; K. V. W. Nicholls (meteorologist, East Africa High Commission), senior meteorologist, British Caribbean Meteorological Service, Trinidad; H. T. Shewan (agricultural survey officer, Gold Coast), principal agricultural survey officer, Gold Coast; B. D. A. Beck, plant breeder, Nigeria; S. R. Chant, plant pathologist, Nigeria; C. M. Grieve, agricultural officer, British Honduras; A. D. H. Joblin, agricultural officer, Uganda; R. G. Poultney, pasture research officer, Kenya; J. H. Proctor, entomologist, British Guiana; R. MacDonald, geologist, Uganda; R. H. Cammack, scientific officer (mycologist), Nigeria; A. G. Smyth, soil scientist, Nigeria; R. F. Coughlan, veterinary research officer, Federation of Malaya; C. J. Price, veterinary officer, Uganda; J. G. Tremlett, veterinary officer, Northern Rhodesia; E. M. McWatt, veterinary officer, British Guiana; T. R. Paton, scientific officer (soil chemist), North Borneo; J. D. Randall, statistician, East Africa High Commission; W. W. Reece, stock development officer, North Borneo; R. A. Eyre-Smith, livestock improvement officer, Kenya; R. L. Sykes, leather chemist, East Africa High Commission; Miss M. S. Timpson, computer, Uganda; R. J. Wedderburn, assistant conservator of forests, Nigeria.

The Night Sky in February

NEW moon occurs on Feb. 14d. 01h. 10m. U.T., and full moon on Feb. 28d. 18h. 59m. The following conjunctions with the moon take place: Feb. 5d. 18h., Saturn 8° N.; Feb. 16d. 23h., Mars 5° S.; Feb. 17d. 09h., Venus 2° S.; Feb. 19d. 14h., Jupiter 6° S. Mercury, in superior conjunction on February 2, is not well placed for observation until later in the month. On February 14 and 28 it sets at 18h. and 19h. 15m., respectively, and can be seen in the western sky after sunset in the latter part of the month. Venus is an evening star and sets at 21h. 05m., 21h. 35m. and 21h. 50m. on February 1, 14 and 28 respectively. The visible portion of the illuminated disk varies between 0·51 and 0·34, and the stellar magnitude is about − 4·2. Mars is visible in the early evening hours, its time of setting being about 20h. 50m. during the month. Its stellar magnitude is 1·3; in the early part of the month it lies a little south of λ Piscium, and towards the end of the month a little south of ε Piscium. Jupiter sets at 1h. 15m., 0h. 25m. and 23h. 45m. on February 1, 14 and 28, respectively, its stellar magnitude varying between − 2 and − 1·8. At the end of the month the planet lies a little south of δ Arietis. Saturn rises at 23h. 40m., 22h. 45m. and 21h. 55m. at the beginning, middle and end of the month, respectively. Its stellar magnitude is 0·3, and it lies a little north-east of α Virginis during the whole of February. Occultations of stars brighter than magnitude 6 are as follows, observations being made at Greenwich: Feb. 2d. 1h. 37·6m., ρ Leon. (*R*); Feb. 4d. 2h. 58·2m., *q* Virg. (*R*). *R* refers to reappearance. A partial eclipse of the sun, invisible at Greenwich, takes place during Feb. 13–14. It begins on Feb. 13d. 23h. 12m. at lat. 21° 55′, long. − 111°, and ends on Feb. 14d. 02h. 45·6m. at lat. 68° 27′, long. 164° 08′. The magnitude of the greatest eclipse is 0·760 (sun's diameter 1·0).

Announcements

THE Third General Assembly and International Congress of the International Union of Crystallography will be held in Paris during July 21–28, 1954. These dates have been chosen in consultation with the French National Committee for Crystallography and with the national committees of all the adhering bodies. Further particulars of the meeting will be given from time to time in *Acta Crystallographica* and elsewhere, or may be obtained from the general secretary of the Union, Dr. R. C. Evans, Crystallographic Laboratory, Cavendish Laboratory, Cambridge.

THE spring conference of the Geographical Association will be held in the Diocesan Training College, Lincoln, during April 7–11, under the presidency of Dr. O. J. R. Howarth. The programme mainly consists of excursions of various sorts, but, in addition to the usual social functions, there will be a number of lectures, including the presidential address for 1952 by Prof. F. Debenham, and also an exhibition of maps, plans, books, etc. Application forms, which must be returned by February 16, and further information can be obtained from the honorary conference secretary, Miss Margaret Goodrich, Training College, Lincoln.

A SYMPOSIUM on molecular structure and spectroscopy, on the lines of those of previous years, will be held in the Department of Physics and Astronomy, Ohio State University, during June 15–19. The interpretation of molecular spectroscopic data as well as methods for obtaining such data will be discussed, and, in addition, there will be sessions devoted to aspects of spectroscopy which are of current interest. Further details can be obtained from Prof. Robert A. Oetjen, Department of Physics and Astronomy, Ohio State University, Columbus 10, Ohio.

LIST No. 7 (pp. 77, December 1951) of "Scientific Papers published in the Middle East", now issued by the Middle East Science Co-operation Office, Cairo, includes the papers received by that Office during November 1, 1950–September 30, 1951, and covers Afghanistan, Cyprus, Egypt, Iran, Iraq, Israel, Lebanon, Pakistan, Sudan, Syria and Turkey. There is the usual list of periodicals, arranged by country; the papers themselves are arranged by sciences and technologies according to the decimal classification.

THE Ministry of Agriculture and Fisheries is offering the following scholarships for rural workers, or the children of rural workers, of seventeen years of age or more: ten senior scholarships, tenable at universities or colleges, for degree or diploma courses in an agricultural subject or veterinary science; sixty junior scholarships and six extensions for existing holders, tenable at farm institutes, for one-year courses. Selection is by interview only. Further information and forms of application (to be completed by March 31) can be obtained from the Secretary (Room 314), 1 Cambridge Terrace, Regent's Park, London, N.W.1, or from the education offices of County Councils.

GEOPHYSICAL PROSPECTING

THE European Association of Exploration Geophysicists held its third meeting at the Stadthalle, Hanover, during December 3–5. More than a hundred and fifty members and guests from various countries in Europe and the United States attended. At the business meeting held on the first day, the final arrangements for the publication of the Association's journal were announced and approved. The journal will be entitled *Geophysical Prospecting* and will be published quarterly, the first issue appearing, probably, in March. Twenty papers were presented at the technical sessions. They comprised ten on seismic, seven on gravity, one on magnetic and two on electric problems of prospecting.

Few people outside Germany are aware of the remarkable progress which has been made by geophysical firms in that country in the application of seismic methods underground in mines. The location of faults, metalliferous veins, and the accurate mapping of sinuous or faulted veins are problems on which considerable successful work is being done, and one of the papers presented at the meeting, by H. Linsser (Germany), described the interpretation of the seismic sub-surface records by a statistical method designed to improve accuracy. An interesting description was given by H. von Helms and H. W. Maas (Germany) of recent marine seismic observations undertaken in the Baltic Sea. By means of these observations, perhaps the first of their kind to be made off a European coast, it became possible to fill in the gaps of a seismic section observed on land between Flensburg and Kiel.

The existence of multiple reflexions sometimes causes difficulties in the interpretation of seismic reflexion records. It has been the general tendency for these multiples, when they exist, to occur in areas which, structurally, have been little disturbed, but a paper submitted by H. Richard (France) demonstrated the existence of multiples in certain areas marked by steep dips and faulting. A particularly interesting case was the simultaneous recording of multiple reflexions from horizontal beds within a graben, and other oblique multiple reflexions from the steeply inclined beds at the boundaries of the graben. In describing the possible paths traversed by the reflexions, the author made some startling suggestions and introduced conceptions which were novel. The succession of seismograms obtained along a section across the graben, when placed in sequence below each other, furnished an unusual picture of the shape of the geological structure, the vertical lines of reflexions in the early parts of the seismogram depicting the horizontal beds within the graben and the later oblique lines of reflexions, forming overall the shape of a V, depicting the two inclined boundaries of the graben.

The subject of wave-energy return by diffraction from faulted beds, already discussed at a previous meeting in London[1], was again raised through a paper presented by R. Koehler (Germany). A practical example was described which suggested that 'reflexions' caused by diffraction can almost certainly be detected if they arise from shallow beds in a faulted area with wide fracture zone; but the effect from deeper beds is negligible. Two papers, from J. Schoeffler (France) and H. J. Dürbaum (Germany), dealt with the frequently considered problem of improving seismic interpretation by taking into account the departure of the actual ray-paths from the normally assumed straight-line paths.

The Department of Geophysics of the Amt für Bodenforschung, with the co-operation of the oil companies concerned, is engaged in a compilation of the data furnished by well velocity-surveys carried out in north-west Germany, on the lines of a similar compilation undertaken in the United States which has been of considerable value to American geophysicists. The results of this German work to date, based on seventy-four well velocity-surveys carried out during a period of eighteen years, were described. The data covered depths down to nearly six thousand feet, and interesting comparisons were made with the corresponding data from the United States.

A useful electronic device for overcoming the effects of static on seismic shot signals was described in a paper submitted by A. T. Dennison and F. A. Roberts (Great Britain). Pronounced static can cause serious delays in seismic long-range refraction surveys, and a device such as this should prove invaluable in these circumstances.

The seismic session of the meeting was rounded off with two interesting papers describing methods of ascertaining the velocity of sound waves in rock samples. In a demonstration of the first method, by H. Baule (Germany), supersonic pulses were transmitted through a cylindrical core of the rock specimen by a magnetostrictive driver attached to one end. The pulses were received at any chosen distance along the core by a small crystal pick-up resting on the specimen. The transmitted pulse and the wave form of the received disturbance were displayed stationary on a cathode-ray tube, together with a time scale furnished by a quartz clock, and the travel-time could thus be measured. Observations made at different distances enabled a time-curve to be drawn from which the velocity could be accurately determined. The second method, described by E. Müller (Germany), has the advantage that only quite small specimens of the rock are required. The sample is prepared by making a single cut, so as to produce a plane face, and then it is dipped in a fluid of known sound velocity. On the plane face of the sample a minute explosion is produced by an electric spark, and the two wave-fronts produced in the fluid by the longitudinal and transverse waves propagated through the specimen are photographed by the schlieren method. The angles between each wave-front and the plane surface of the specimen are measured, and the velocities and elastic constants thereby determined.

The session on gravity prospecting opened with a paper by B. J. Hofman (Holland) describing developments in marine gravity surveying. Experience has shown that remote-control underwater instruments have many advantages, and operational costs using such instruments are lower than with other systems utilizing land instruments on tripods or in diving bells.

The uses of the first, second and even higher derivatives of gravity in the interpretation of field observations were considered in papers by V. Baranov (France), O. Rosenbach (co-authors R. Koehler and E. Wirth) and B. Kosbahn (Germany). A particularly interesting contribution by S. Saxov (Denmark) shed considerable light on the relative

values of the various derivative methods in emphasizing structural anomalies at different depths.

Prof. J. Goguel (France) described certain features of the geological interpretation of the gravity map of the Paris basin, and Prof. O. Vecchia (Italy) gave a detailed account of the regional structure of northern Italy deduced from gravity measurements. The results of magnetic investigations over the palæozoic massif of Serpont, in Belgium, were described by C. Gaibar-Puertas (Spain) and E. Hoge (Belgium). The applications of conformal representation in the interpretation of the results of telluric current surveys were considered in a detailed communication by G. Kunetz and J. C. de Gery (France). The final paper at the meeting dealt with the application of geophysics in the search for further supplies of drinking-water in Western Germany, and it is interesting to learn that considerable success has attended the application of geoelectrical measurements in quite a number of the hydrological problems which are involved. D. T. GERMAIN-JONES

[1] *Nature*, **170**, 230 (1952).

SCIENCE MASTERS' ASSOCIATION

ANNUAL MEETING

THE annual meeting of the Science Masters' Association was held in the Chemical Department of the Royal College of Science, London, S.W.7, during December 30, 1952–January 2, 1953. The general theme of the meeting was "Science in the Service of the Community", and, with the co-operation of the heads of the science departments of the Imperial College of Science and Technology, the Science Museum, the Metropolitan Police Forensic Laboratory, the scientific departments of the London County Council and members of the Association, the widespread use of science in the modern world was adequately and realistically displayed.

In his presidential address, Sir Graham Savage, until recently the education officer to the London County Council and previously for many years chief staff inspector to the Board of Education, made a survey of the teaching of science during the past hundred years. He illustrated his talk by quotations from many sources not usually met with in the normal educational circles, and concluded by looking forward to a possible expansion of scientific teaching, expressing the hope that greater freedom would be granted to the qualified teacher to enable him to make the most of the material at his disposal or of that which he might be allowed to acquire.

Mr. L. C. Nickolls, director of the Metropolitan Police Forensic Laboratory at New Scotland Yard, London, in a lecture enlivened by many touches of humour, described the application of scientific methods dealt with by his Department. Illustrating his lecture by examples taken from his own wide experience, he emphasized the necessity for wisdom or common sense, as well as for highly skilled technical knowledge, in the solution of practical problems. He appealed to science masters to try to instil into their students the need for wisdom. At present, he said, too many highly skilled workers are becoming technicians, and too few are becoming scientists. Forensic science demands the use of a little science but a lot of common sense as, for example, when a member of his staff identified by means of detailed analysis two specimens of paint as containing the same metallic elements and declared them identical, while omitting to observe that one was green and the other brown. Mr. Nickolls described the work of his Department as falling under four headings: to tell whether a crime has actually been committed; to say who did it; to supply corroborating evidence; and to increase the weight of the evidence when the cases are presented before the courts. These points were most adequately illustrated by photographs of activities which had been brought to the notice of the Laboratory.

The heads of the Departments of Botany, Physics and Organic Chemistry of the Imperial College of Science and Technology—Prof. W. Brown, Prof. S. Devons and Prof. R. P. Linstead, respectively—described work done recently in their Departments. Prof. Brown, in dealing with the problem of plant diseases, said that it would be possible only to skate lightly over the field of study of pathology in plants. His aim, therefore, would be to give the main lines along which one proceeds to deal with the problem. As contrasted with veterinary, and especially medical, work, the methods of plant pathology have to deal almost entirely with populations and not with individuals. Inasmuch as a plant disease almost invariably damages the plant so that it rarely recovers, the plant pathologist is more concerned to ward off disease than to deal with it once it is fully established: the adage, 'prevention is better than cure', appeals to him with particularly strong force. The lines of defence include such things as improved cultural practice, protective fungicides and bactericides, breeding of resistant types of plants and the control of the spread of infective material. In connexion with the last-named, there exists considerable legislative repercussions for the unwary. Prof. Brown's lecture was illustrated by museum specimens, cultures of pathogenic organisms and with lantern slides. Prof. Devons dealt with the electromagnetic radiation from the nuclei, discussing the factors involved and the methods used in investigating the phenomenon. Prof. R. P. Linstead discussed the oxidation-reduction systems and, in particular, the hydrogen transfer from donor to acceptor molecules, giving as the most remarkable those changes which take place in the living cell. The mechanism of some transfers of hydrogen and the energy changes involved were discussed.

Mr. F. A. Meier, of the University of London Institute of Education, gave one of his customary lecture demonstrations, this time on a theoretical and experimental approach in the teaching of the M.K.S. systems of electrical units. Mr. Meier can always be relied upon to attract and hold the attention of a large audience of physicists, and this year was no exception to the rule.

New semi-micro experiments and their application to qualitative analysis were described by Mr. H. Holness, of the South West Essex Technical College. This was followed by a visit to the College, where students demonstrated the new techniques and apparatus, and where members were given an opportunity of using some semi-micro apparatus for themselves. Dr. F. Sherwood Taylor, director of the Science Museum, South Kensington, outlined the work there, both in a lecture and by a tour of the Museum. He described his efforts to increase the co-operation between the schools and the Museum, and to display to the general and to the specialized

and informed public alike how scientific achievements have and can impinge upon the life of mankind. Dr. Sherwood Taylor also indicated that were there a suitable demand he would be prepared to consider following the lead of the National Gallery and organize exhibitions of museum material outside London.

Dr. T. P. Colclough, of the British Iron and Steel Federation, showed how increased efficiency in the manufacture of steel depends upon the skilful use of the scientific worker, and that the industry, with its equipment costing millions of pounds, can only function successfully if science is applied at every stage and in every process; there is therefore a need and an opening for more, and for more highly trained, scientists.

The Departments of the Medical Officer of Health and of the County Engineer of the London County Council provided lecturers and demonstrations of the direct application of science in modern life. An informative lecture upon the drainage of London from the earliest times to the present day, with a discussion of the many problems involved, showed how life in a congested city can be maintained and also the risks to which those who are involved in the sewerage system are exposed. A colour film of this work was shown in the County Hall, London, after which the laboratories of the Chemist-in-Chief were inspected. In these laboratories more than twenty-five thousand samples are investigated annually, including samples of air from the London tunnels, water from the rivers, from the wells in the Council's institutions, from swimming pools and baths, paints and building materials, laundry materials and fabrics with their resistance to washing, and the control of all stages of sewage treatment. Time permitted only a brief inspection of the extensive display set out by the twenty-six graduate chemists and their twenty-eight assistants.

However, the most spectacular lecture of the meeting was undoubtedly that given by Dr. C. W. W. Read, director of education for West Sussex and chairman of the West Sussex Beekeepers Association, who showed how a method has been devised for inseminating instrumentally the virgin queen honey-bee while still in captivity. Hitherto mating has been done on the wing and therefore beyond human control. A special micro technique is involved, and this was demonstrated both by means of the apparatus and by a coloured film of all the processes involved. By suitable sized screens in the hives, the queen bees and the males can be separated from the 'workers'. The drones can then be marked for identification purposes, so that the males used may be those carrying known breeding characteristics. The virgin queen honey-bee and the drones are anæsthetized in carbon dioxide under suitable conditions, the semen collected from the males and, by the use of micro seekers and a micro pipette, 5 cu.mm. of semen is injected into the virgin queen bee. In this way complete control is exercised, and any type or strain can be bred. As five generations a year can be obtained, the purity of the strains produced can be recognized in a short time. The film which illustrated the lecture deserved all those adjectives that are often reserved for the commercial cinema.

As usual, one of the most useful features of the meeting was the display of apparatus and teaching devices made by the members, which extended from cotton reels and their uses in physics to "Nuclear Disintegration by Cosmic Rays". The programme for each afternoon consisted of visits to laboratories, institutions and works, all of which had a high scientific value. A reception was held in the County Hall, London, on the evening of January 1.

Nearly nine hundred signed the register of attendance, every part of the British Isles and many countries overseas being represented.

INDUSTRIAL CHEMICAL EQUIPMENT IN THE UNITED STATES

IT is an accepted fact that during the present century the chemical industry has developed at a far greater rate in the United States than it has in Europe. At the beginning of the First World War, Europe was the main centre for the production of chemicals, and the output in the United States was comparatively small; at present it is estimated that two-thirds of the world's supply of synthetic organic chemicals originates in the United States. It is to be noted, however, that Europe still excels in the making of original scientific discoveries; it is in the rapid development of these discoveries to industrial processes that the United States appear to show such marked superiority. Typical examples are detergents, penicillin, streptomycin, many plastics, silicones and chemicals made from petroleum, all of which could be bought in the United States before being made on the eastern side of the Atlantic. The main reason for this is usually ascribed to the very large number of chemical engineers available in the United States for development work, and the very small number trained elsewhere, the ratio being of the order 20 to 1 so far as Great Britain is concerned. During the past few years numerous reports and discussions have emphasized this state of affairs, and many recommendations have been made for training chemical engineers in much larger numbers.

The latest approach to the subject is wider in scope and is a report* entitled "Chemical Apparatus in the U.S.A." made to the Office of European Economic Co-operation by a group of experts who visited a number of American firms. The title is not a happy one, as it fails to convey the expressed object of the mission, which was to investigate so far as possible the reasons for the great development of the American chemical industry. It is obvious that such a task would be beyond the powers of any small body of men in a reasonable time, and consequently the mission has been forced merely to mention some of the causes of development and, after contact with some twenty manufacturing firms, to write more detailed accounts of a few selected operations. The result is bound to be unbalanced, but it is, none the less, very readable. Another difficulty with which the mission had to contend was the use of the term 'Europe' as the antithesis of 'United States'. Europe is still far from being one country, especially where chemical engineering is concerned, so that to state that a process or machine is not commonly used in Europe may be quite accurate where some of the component countries are concerned, but incorrect in other cases. This is particularly noticeable in the

* Chemical Apparatus in the U.S.A. Technical Assistance Mission No. 23. Report by a Group of European Experts. Pp. 224. (Paris: O.E.E.C.; London: H.M.S.O., 1952.) 20s. net.

case of chemical engineering training, the description of which in Europe can scarcely be taken to apply to Great Britain.

In Part 1 the authors discuss the factors which tend to give American manufacturers an advantage over corresponding firms in Europe. Some of these are as follows: more chemical engineers; superior natural resources; larger home market; stronger internal competition; more vigorous sales methods; greater interest in new processes, products and materials; breaking down of development projects into simple units each dealt with by specialists; greater use of sub-contractors; more standardization, internal and external; greater readiness of firms to publish process details; availability of much empirical information; superior methods of transport and storage; and more instrumentation and automatic control.

It seems probable that the rise of the chemical engineer in the United States was originally due to the requirements of the oil industry. His success in this department led naturally to a call for chemical engineers in other branches of the chemical industries, and the cumulative effect was to produce the present large numbers, many of whom are employed successfully in industries not directly connected with chemistry. It is interesting to note, however, a serious decline in the number of new graduates in the subject, the 1953 figure being estimated at only 36 per cent of that for 1950. This decline is common to other branches of engineering, and a similar trend may be observed in Great Britain.

Many of the advantages listed above are directly dependent on size; thus the larger the connexions of a specialist firm of equipment makers, the more designs can they hold from which to suit a customer and the more can they spend on research. The report emphasizes the attitude of American manufacturers towards new projects, but fails to mention the deterrents which exist, particularly in Great Britain, in the shape of restrictive regulations, insufficient obsolescence allowance, the risk of loss and, in the event of success, the confiscation by taxation of a large percentage or sometimes nearly the whole of any gains. It is surprising that, in these circumstances, development proceeds at all.

Part 2 contains articles on process instrumentation, catalytic processes, distillation and extraction, heat exchange, special equipment, materials of construction, and transport and storage. With the exception of the first, these savour somewhat of the text-book, although an attempt is made to direct attention to plant and methods which are more commonly used in the United States than in Europe. The twenty-six pages devoted to instrumentation give a clear picture of the extent to which automatic control is used in the United States, and thirty-five diagrams indicate the variety of ways in which it can be applied, as well as showing some of the most modern instruments. It is emphasized that automatic control is not merely a device for saving labour, but that the operation of many modern plants would be impossible without it.

The report itself is highly condensed and it is difficult in a brief notice to give an adequate idea of its contents. Few chemical or plant manufacturers, however, bearing in mind the limitations already referred to and reading the subject-matter in an inquiring rather than in a critical manner, will fail to find ideas or suggestions for which they may be grateful.

H. E. Watson

ATOMIC ENERGY RESEARCH AT HARWELL

THE main research programmes of the Atomic Energy Research Establishment at Harwell since its inception in 1946 to the end of 1951 are described in a fascinating and connected story of the work and problems of the Establishment, which is the first of its kind to be published*. Some of the information has already appeared in scientific journals, but this new account is presented in a fashion which it is hoped will appeal to the more general reader. The subject, however, is far too technical to be appreciated and understood by any but those who have at least a background knowledge of the physics and chemistry of the atom.

Harwell is only a part, but an important central part, of the British atomic energy project. It has been given two main tasks: to conduct research into all aspects of atomic energy, and to advise the production organization and furnish it with the scientific and technical information that it needs. The atomic pile or nuclear reactor is obviously the primary requirement, and the two Harwell piles—'Gleep', the Graphite Low Energy Experimental Pile, which has been in almost continuous operation since August 15, 1947, and 'Bepo', the British Experimental Pile 0, which was started up on July 3, 1948—have proved invaluable research tools. Full descriptions of these reactors have been published previously, but, for convenience, these are reproduced in an appendix to the volume. Gleep operates at 100 kW., and Bepo, roughly of the same size, operates at 6,000 kW. with air cooling and is mainly concerned with the production of isotopes. These piles have been used to help solve problems in the design of the Windscale production piles, the main function of which is to produce plutonium. This branch of the work is briefly considered in the third of the nine sections into which the volume is divided. Other sections deal with the production and distribution of radioisotopes, perhaps the most widely publicized aspect of the work at Harwell; nuclear reactors and the production of useful power; particle accelerators, their purpose and the various forms in use at Harwell; methods of detection of radiation and of protection of atomic energy workers against damage to their health by exposure to radiation; the fundamental research programme involving chemical, physical and metallurgical investigations (engineering, biological and chemical-engineering work will be described in subsequent publications); and Harwell's extra-mural relations in the two important categories: collaboration through research and development contracts placed with academic, industrial or government laboratories, and exchange of scientific and technological ideas and information through published work, lectures, training schools and conferences.

To the general reader the sections on radioisotopes and on radiation protection will make most appeal. Present deliveries of isotopes, including those of long life which two years ago could be obtained only from the United States, now number eight hundred a month, and an increasing proportion is now made by air transport to many overseas customers. Various applications of radioisotopes in biological, medical and industrial fields are described. The use of cobalt-60 in place of radium is not so well known as

* Harwell: the British Atomic Energy Research Establishment, 1946–1951. Pp. 128+32 plates. (London: H.M.S.O., 1952.) 6s. net.

it should be, and the recent introduction of radioactive sodium for skin-graft operations is an important advance in plastic surgery. The protective measures taken at Harwell give some indication as to how much protection the general public may be able to get in atomic warfare. The instruments devised for the detection of radiation are sensitive and accurate. The frog-suit and helmet that are worn by those who have to come into contact with highly contaminated areas are somewhat frightening, as shown in the illustration given; but nevertheless it is reassuring in that these workers can be thus protected.

In the sections dealing with fundamental aspects, the research and technical worker will find some interesting information. Among the topics discussed are the study of the unusual crystal structure of uranium, which is orthorhombic at room temperature (some more details have recently been published in an article by Dr. H. M. Finniston in *Times Sci. Rev.*, No. 6; winter 1952); the effects of irradiation on the physical properties of crystals and glasses; neutron diffraction; the splitting of carbon into three, and oxygen into four, helium nuclei by high energy X-rays; powder metallurgy, principally of beryllium, zirconium and niobium; and research on ceramics.

It would appear that the compilers of this excellent volume intend to encourage the average student of science to extend his knowledge of nuclear physics, and to assist him in this commendable purpose they provide, in an appendix, a list of books suitable for the non-scientist, another list for students up to honours degree standard, and in addition a list of papers on the generation of useful power from nuclear energy. Perhaps further accounts, similar to "Harwell", to bring the story up to date will aim at particular sets of readers, possibly one account for the general public and another more technical one for the student of nuclear energy in its various aspects.

THE WORK OF G. F. FITZGERALD

A SPECIAL meeting of the Royal Dublin Society was held on October 30, 1951, to commemorate the centenary of the birth of George Francis FitzGerald (see *Nature*, **168**, 930; 1951). A message of greeting was read from the president of the Institution of Electrical Engineers, of the Irish branch of which Prof. FitzGerald was the first chairman. The Physical Society, London, was represented by Prof. K. G. Emeléus, and personal messages of congratulation, received from Sir Edmund Whittaker and from Dr. G. F. C. Searle who remembered FitzGerald personally, were conveyed to the meeting by Prof. F. E. Hackett. Slides and exhibits of some of FitzGerald's models, letters and experiments were shown.

The major part of the meeting was devoted to the reading of five papers dealing with FitzGerald as a man and a scientific worker and with the FitzGerald–Lorentz contraction and its relation to the theory of relativity. The text of these papers, together with two illustrations of FitzGerald as he was in 1878 and 1897, is included in the FitzGerald Memorial Number of the *Scientific Proceedings of the Royal Dublin Society**. In the first paper, Prof. Hackett discusses the character of FitzGerald as revealed by his letters to Heaviside and gives examples of the several brilliant suggestions proposed but not actively pursued by FitzGerald. This is followed by a paper by Prof. H. E. Ives, who, after a brief historical survey of the FitzGerald contraction, derives, using the method of approach of Poincaré's principle of relativity instead of the more usual invariance of the Michelson–Morley experiment, the exact value of the FitzGerald contraction together with the accompanying change of clock frequency perceived by Larmor. Prof. Ives concludes with a brief discussion of the experimental evidence for the contraction and adds some interesting remarks concerning the ether.

Prof. W. H. McCrea discusses some paradoxes of the FitzGerald contraction and their resolution, and Dr. G. J. Whitrow the theories of relativity of Galilean frames with particular reference to E. A. Milne's work. Finally, Prof. J. L. Synge, in a paper entitled "Effects of Acceleration in the Michelson and Morley Experiment", offers an explanation, which he admits may appear fantastic but which is capable of direct experimental test, of D. C. Miller's observations in his 1933 repetition of the Michelson–Morley experiment. The explanation is based on G. H. F. Gardner's theory of the behaviour of a rigid body in accelerated motion. Because of the horizontal position of the interferometer, the original Michelson–Morley experiment is extremely poor as a check on Gardner's theory. An interferometer firmly integrated with the earth and with at least one of the two arms of the interferometer inclined at 45° to the horizontal is required, and such an instrument, Prof. Synge estimates, even with an arm-length of only 20 cm., compared with Miller's 3,000 cm., would give a fringe shift of a full fringe on rotation about a vertical axis. Reference may be added here to an experiment on these lines made by Prof. R. W. Ditchburn and O. S. Heavens (see *Nature*, **170**, 705; 1952).

* *Scientific Proceedings of the Royal Dublin Society*, **26** (N.S.), No. 1: Fitzgerald Memorial Number. Pp. 54+3 plates. (Dublin: Royal Dublin Society, 1952.) 12*s*.

AMERICAN–ASIAN FLORISTIC RELATIONSHIPS

THE floristic relationship between eastern Asia and eastern North America is the subject of a considerable memoir by Hui-Lin Li (*Trans. Amer. Phil. Soc.*, New Ser., **42**, 2, 371; 1952), the subject being one which has interested plant geographers ever since Asa Gray's important paper on the subject in 1840.

While the present work broadly confirms the basic ideas established one hundred years ago, it reviews and revises the data in the light of modern concepts of taxonomy, nomenclature, plant geography and genetics. There is, in fact, a close floristic relationship between eastern Asia and North America, this being particularly marked in the east. Many genera which are common to, and dominant elements in, the two floristic regions have also a wide, general distribution and are therefore less useful in establishing relationships between the two continental regions. But there are many other less widespread genera which are of particular value in this study. Those genera, common to both continents, which are better developed in western than in eastern North America are considered as primary genera of western North America, whence they have spread eastwards into eastern North America and westwards into adjacent parts of north-eastern Asia. Their range is thus more or less continuous.

Leaving aside the many pan-tropical genera, a number of tropical and subtropical genera are known

to occur in eastern Asia and in Central America and Mexico, these exemplifying a discontinuous distribution. Temperate and tropical genera which are especially confined to eastern Asia and eastern North America are enumerated. These include trees, shrubs, herbs and vines, some 38 genera being recorded for temperate regions and 19 for tropical regions. These genera are not necessarily of the same geological age and origin, but the evidence indicates that the majority have formed associations with each other and some of them may have been the dominant elements of past floras.

An interesting point is that many of the genera under consideration are of relative antiquity in the phylogenetic scale; they include, for example, ancient genera like *Liriodendron*, *Magnolia* and *Sassafras*, of which reliable fossil records have been obtained. The species of the genera of the two disjunct areas are in most cases sharply defined and, in practically all cases, are different in the two continents, such differentiation being attributed to, or affording evidence of, the long isolation of the two floras. It is in this connexion that later workers have been able to correct the work of Gray and others; for many of the species from the two regions originally considered to be identical have now been demonstrated to be distinct. The truly identical species are found in the colder northern regions and have typically a continuous distribution. Many of these species are very widely distributed, some being typically circumpolar or circumboreal. They comprise plants which are characteristic of the glaciated regions of North America and Europe and are apparently of more recent origin than the disjunctive genera of the temperate region. These are but a few of the points brought out in this unusually interesting survey.

EXTRA-CELLULAR PHOTOSYNTHETIC REACTIONS IN ENTIRE LEAF MACERATES

By Dr. F. C. GERRETSEN

Department of Microbiology, University of Groningen

IN a recent article in *Nature*, Prof. D. Arnon[1] discusses the possibility of extra-cellular photosynthesis. His view that a rather straightforward experimental approach to this problem by using entire leaf macerates does not seem promising, because the stability of the photolytic system in isolated chloroplasts undergoes rapid deterioration, is not shared by me. Though in many cases leaf macerates are indeed useless for the purpose, at least in one case this is not so, namely, in the case of macerized *Avena* leaves. (In more recent studies macerates of young leaves of *Beta vulgaris* also gave satisfactory potential changes on illumination.) Studying the role of manganese in photosynthesis[2], it was proved that filtered cell-free suspensions of crushed *Avena* leaves show a pronounced photo-reactivity for several hours and that an illuminated suspension even retains its reducing power during a dark period of 1–2 hr. following illumination.

Illumination of crude *Avena* chloroplast suspensions generally brings about large and rapid changes of the redox potential as measured with a bright platinum electrode. As the potential of such a complicated and heterogeneous system depends on a number of unknown factors, one has to be very cautious in drawing any definite conclusions from the observed changes; in a number of cases, however, valuable information was acquired concerning the nature of the oxidation-reduction processes occurring during illumination in these suspensions.

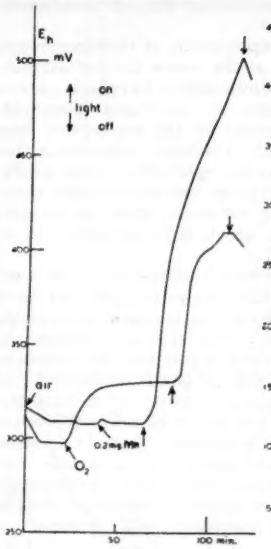

Fig. 1

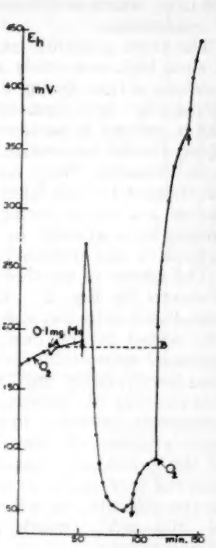

Fig. 2

Fig. 1. Redox potential curves of entire leaf-macerate of two identical leaves of the same oat plant, with and without manganese ions. The addition of manganese has no effect in the dark (↓); on illumination (↑) the potential rapidly rises to 500 mV., indicative of the formation of peroxide. *p*H 6

Fig. 2. Redox potential curves of leaf macerates. Note (1) that the entire leaf suspension retains its capacity to hydrogenate oxygen in the dark, 45 min. after illumination has been stopped (↓); (2) difference in behaviour at the equipotential points *A* and *B*, which refer to the same macerates in the dark, the only difference being that *B* had been illuminated previously

As may be seen from the accompanying graph (Fig. 1, lower curve) the addition of oxygen to an entire chloroplast suspension in the dark causes the potential to increase insignificantly by about 25 mV., after which it remains constant for about 50 min. When the suspension is illuminated, there is a sudden rise of the potential of more than 150 mV. up to 410 mV.

In the second curve, 0·2 mgm. manganese as manganese sulphate is added in the dark to an analogous suspension, which does not influence the potential. Illuminating this suspension, the potential increases much more and even reaches a maximum of 500 mV. (calculated on the basis of the normal hydrogen electrode).

This experiment, which is representative for a series of experiments of the same nature, shows, in the first place, that the crude chloroplast suspension has retained its photosensitivity for nearly two hours; illumination causes a rapid shift towards a more oxidized state. After the addition of manganese ions the potential rises to a much greater height and reaches 500 mV., which might be indicative of the formation of a peroxide.

The mean maximum value of a series of ten different determinations after the addition of 0·1–0·2 mgm. manganese ions as manganese sulphate to 8 ml. suspension and during illumination was

505 mV., which is 153 mV. higher than in the absence of manganese.

The most plausible explanation of the occurrence of such high potentials in the crude chloroplast suspensions is that during illumination oxygen is photochemically hydrogenated to hydrogen peroxide, which process is accelerated by the manganese ions added to the suspension[2]. Gaffron[3], supporting this view, remarks, "Such an interpretation seems likely, for Mehler[4] in this laboratory has shown that manganese ion has a strong catalytic effect on oxygen uptake by a system, in which H_2O_2 is known to be formed in this manner".

The course of another very instructive experiment is shown by Fig. 2. After some oxygen had been introduced into the suspension, manganese sulphate was added in the dark; this did not change the potential appreciably. On illumination, the potential rises very quickly until the oxygen is exhausted; at this moment the potential decreases very rapidly and ultimately reaches a minimum of 52 mV. When the light is turned off, there is generally a slight increase of the potential. Introducing oxygen in the dark into the suspension 20 min. later causes the potential to rise 260 mV. in a few minutes, reaching a height of 365 mV., which increases still further on illumination.

Comparing the equipotential points *A* and *B*, we notice that in both cases oxygen had been recently introduced, manganese ions are present at both points and both are in the dark; the only difference is that *B* had been illuminated 40 min. previously. In this case also these high potentials are indicative of the formation of peroxide, and the capacity of the dark suspension at *B* to hydrogenate oxygen can only be explained by the presence of some strongly reducing compound, which had been formed during illumination and persisted during the dark period. In another case a rise of 180 mV. was observed on the addition of 0·1 mgm. manganese in the dark to a suspension, 115 min. after illumination had been stopped, whereas the addition of the same amount of manganese to a similar unilluminated suspension had no effect.

These experiments are further strong evidence for the existence of a relatively stable intermediary reduction compound, persisting during a dark period following illumination, which has been postulated by van Niel[5] and others[6] and the existence of which had been made plausible by Calvin and Benson[7] with the aid of carbon-14.

In a paper read at the annual meeting of the Society for Experimental Biology at Oxford in April 1949, I showed that when entire *Avena* leaf macerates are illuminated under anaerobic conditions and in absence of carbon dioxide, changes of the redox potential are small, whereas the *p*H remains constant or slowly becomes more acid. After the addition of a small amount of carbon dioxide there is first a small increase of the E_h due to acidification of the suspension, which now on illumination shows rapid decrease of potential of more than 150 mV. within 25 min. (see Fig. 3). At the same time the *p*H becomes more alkaline, whereas in the previous period without carbon dioxide the *p*H became more acid and the macerate did not react on illumination. When the light is turned off, the reverse is observed.

Though it is not suggested that this is an indisputable proof of photosynthesis *in vitro*, it seems likely that the rapid change of the E_h and the

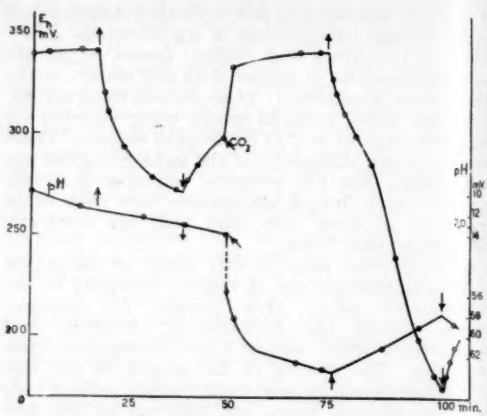

Fig. 3. Influence of the addition of carbon dioxide to an entire leaf macerate on the redox potential and *p*H. Before the addition of carbon dioxide, the E_h soon tends to reach a minimum of about 260 mV. at illumination. The *p*H slowly becomes more acid and does not react on illumination. After the addition of carbon dioxide, the E_h rapidly reaches a much lower value and the *p*H becomes more alkaline on illumination, most probably indicating that carbon dioxide partakes in the photosynthetic reactions

alkalinization during illumination after the introduction of carbon dioxide both point to participation of the carbon dioxide in the oxido-reduction reactions of the chloroplast suspension. The amount of carbon dioxide which disappeared during illumination, calculated from the change of the *p*H, is equal to 2–4 per cent of the amount of carbon dioxide used by the same area of intact leaf-surface during normal photosynthesis.

These few examples will serve to show that experiments with entire leaf macerates can procure valuable information on extracellular photosynthetic reactions. This does not, of course, imply that experiments with isolated chloroplasts will not be indispensable to disentangle the complicated photosynthetic apparatus.

[May 28.

[1] Arnon, D., *Nature*, **167**, 1008 (1951).
[2] Gerretsen, F. C., *Plant and Soil*, **2**, 159 (1950).
[3] Gaffron, H., *Ann. Rev. Plant Phys.*, **2**, 87 (1951).
[4] Mehler, A. H., *Arch. Biochem.*, **34**, 65, 339 (1951).
[5] van Niel, C. B., see Franck, J., and Loomis, E. W., "Photosynthesis in Plants" (Ames, 1949).
[6] Rabinowitch, E. I., "Photosynthesis" (New York, 1945).
[7] Calvin, M., and Benson, A. A., *Science*, **107**, 476 (1948).

SEPARATION OF NEUTRAL PROTEINS ON ION-EXCHANGE RESINS

By N. K. BOARDMAN and Dr. S. M. PARTRIDGE

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ION-EXCHANGE resins have been used to purify basic proteins of low molecular weight such as lysozyme[1], ribonuclease[2] and cytochrome *c*[3], and a separation of the active substances in a preparation of adrenotropic hormone has recently been reported[4]. We have recently endeavoured to extend the range to neutral proteins such as the hæmoglobins. As in previous work in this field, the resin adopted

for these experiments was the monofunctional carboxylic acid cation exchanger 'Amberlite *IRC* 50'.

Paleus and Neilands found that cytochrome *c* could not be eluted from a column of '*IRC* 50' with 0·1 *M* ammonium hydroxide – ammonium acetate buffer below a *p*H of 9·9. Our own experiments, however, have shown that the elution of cytochrome *c* from a column of '*IRC* 50' is very dependent on the cation concentration in the eluting buffer as well as the *p*H. If the cation concentration is greater than 0·22 gm. ions/l., the cytochrome may be eluted at *p*H 7·0. In the work described here, the effect of sodium ion concentration and *p*H of buffer on the adsorption of cytochrome *c* has been studied in detail, and the information gained has been used to predict conditions for the separation of neutral proteins.

Cytochrome *c* was prepared from horse heart muscle by the method of Keilin and Hartree[5], and a chromatographically pure fraction was obtained by adsorbing the preparation on a column of '*IRC* 50' and eluting with sodium phosphate buffer of *p*H 7·0 and sodium ion concentration 0·34 gm. ion/l. This fraction contained 75 per cent of the material put on the column as measured photometrically at 548 mμ but only 55 per cent as measured by the ninhydrin reaction[6]. As impurities in the crude cytochrome preparation, we observed a pale yellow substance[3] which was eluted ahead of the cytochrome band and a red band which remained stationary at the top of the column. This latter band was eluted when the concentration of the buffer was increased and gave the same spectral curve as the main fraction, namely, that for oxidized cytochrome *c*. The main fraction behaved as a single substance when applied to a fresh column of the same resin and could be eluted from it quantitatively. Cytochrome *c* used in subsequent experiments was purified in this manner.

Figs. 1*a* and 1*b* show the effect of *p*H and cation concentration on the elution of cytochrome *c*. The elution volume is unaltered by substituting ammonium for sodium ions and appears to be independent of the nature of the anion. The behaviour of the protein on the resin column, as shown by the continuous line in Fig. 1*a*, is markedly different from that of ampholytes of low molecular weight such as the basic amino-acids. The amino-acid lysine shows a marked maximum adsorption at *p*H 7·3. As the *p*H rises towards its isoelectric point (*p*H 9·7), the lysine is desorbed; and similarly, as the *p*H falls, desorption again takes place due to suppression of the ionization of the resin carboxyl groups. Cytochrome *c* (isoelectric point 10·1) is desorbed in a similar manner to lysine as the *p*H rises from 8 to 10, but is not desorbed under acidic conditions. On the contrary, at *p*H 6–6·5 its elution volume rapidly rises, and under still more acidic conditions the cytochrome band remains stationary at the top of the column.

The broken lines in Fig. 1*a* are plotted from the data of Hale and Reichenberg[7] and Topp and Pepper[8], and show the relationship between the amount of sodium ion taken up by the resin and the *p*H. It will be observed that the rapid rise in the elution volume of cytochrome *c* in sodium buffers occurs over the same *p*H range as the rapid fall in the amount of sodium ion retained by the resin from buffers of comparable concentration. This suggests that the irreversible adsorption of cytochrome *c* that occurs at low *p*H is due to uncharged carboxyl groups on the resin, and that the mechanism of desorption at higher *p*H is concerned with the conversion of the resin to its sodium form. Thus, although electrostatic

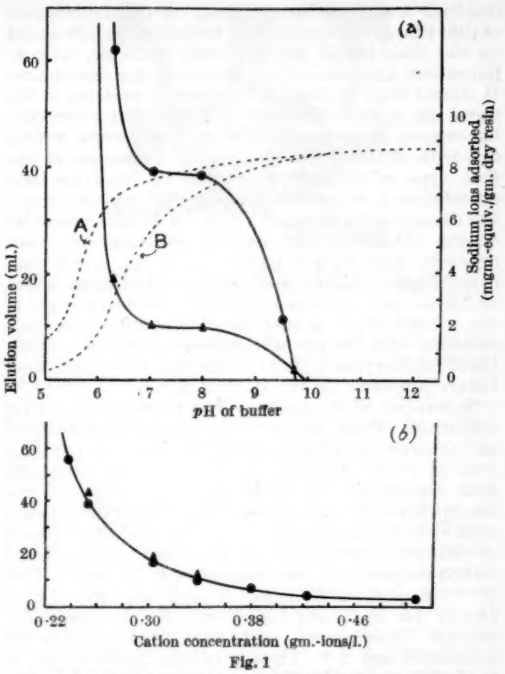

Fig. 1

(*a*) Effect of *p*H on the elution of cytochrome *c* by sodium phosphate buffer. 6·0-mgm. samples chromatographed on columns of 'Amberlite *IRC* 50', 16·0 cm. × 0·9 cm. Rate of flow, 1·0–1·5 ml./hr.; temperature, 25° C. ○, Sodium ions, 0·17 gm. ions/l. △, Sodium ions, 0·34 gm. ions/l. The broken lines show the amount of sodium ion taken up by the resin: *A*, from 1·0 *M* sodium chloride; *B*, from 0·1 sodium chloride

(*b*) Effect of cation concentration on the elution of cytochrome *c*, *p*H 7·0. ○, sodium ions; △, ammonium ions

forces diminish as the *p*H decreases, due to suppression of negative charges on the resin, these forces are replaced by a large increase in the contribution of secondary short-range forces. The increase in short-range forces is most probably due to the concomitant removal of a layer of electrostatically bound water. With substances of high molecular weight, such as the proteins, the contribution of short-range forces towards the net adsorption affinity may be very large, and may be sufficient to account for the apparent irreversibility of adsorption at low *p*H. With amino-acids this contribution will be small, and thus the observed desorption of lysine at low *p*H would be expected.

The interaction of protein and resin may be represented by the following reactions:

$$R\text{–}Na^+ + H^+ \rightleftharpoons RH + Na^+ \quad (1)$$

$$RH + P^+ \rightarrow RH \ldots P^+ \quad (2)$$

$$RH \ldots P^+ + Na^+ \rightleftharpoons R\text{–}Na^+ + P^+ + H^+ \quad (3)$$

$$R\text{–}Na^+ + P^+ \rightleftharpoons R\text{–}P^+ + Na^+ \quad (4)$$

In these reactions short-range secondary forces are represented by $RH \ldots P^+$ and electrostatic adsorption by $R\text{–}P^+$. Reaction (2) represents the mechanism due to secondary forces and lies wholly to the right; (3) shows the desorption of the protein in the presence of sodium ions; and (4) shows the reversible adsorption of the protein due to electrostatic forces.

The electrostatic attraction between protein and resin will depend on the net charge on the protein

molecule and, to a lesser extent, on the distribution of that charge. The secondary forces will be influenced by the chain-length of the protein molecule, its configuration, and also on the nature of the side-chains. It should thus be possible to separate proteins of the same net charge but with different molecular configurations, or proteins of the same molecular weight but with different net charges. An example of the first type of separation is that of lysozyme and cytochrome *c*, which are proteins with approximately the same isoelectric point (10·5, 10·1) and molecular weight (15,000): the elution volumes are very different, and with a column of 5 cm. × 0·9 cm., cytochrome is eluted with sodium phosphate buffer in 3·3 ml. and lysozyme in 26 ml. As an example of the second type, a successful separation has been obtained with bovine carboxyhæmoglobin and sheep fœtal carboxyhæmoglobin, samples of which were kindly prepared by Dr. G. S. Adair.

Separation of the hæmoglobins presents two major difficulties. First, the proteins are readily denatured and at their isoelectric points slowly form precipitates even at 0° C. Secondly, the proteins are isoelectric near neutrality and thus the flat section of the adsorption – *p*H curve between *p*H 7 and *p*H 9 found with cytochrome *c* is absent. The isoelectric points of bovine carboxyhæmoglobin and sheep fœtal carboxyhæmoglobin are respectively 7·3 and 6·7 at 0° C. in phosphate buffer of ionic strength 0·02 [9]; but in the *M* citrate buffer used for the chromatographic experiments, their isoelectric points lie between 4 and 5 [10]. Thus in citrate buffer at *p*H 6, both proteins have a net negative charge, and neither is adsorbed by the resin. On the other hand, as is shown in Fig. 1*a*, at *p*H 5 the carboxylic groups of the resin are almost wholly undissociated, and adsorption of the hæmoglobins is complete and irreversible. The elution volume – *p*H data of the hæmoglobins may thus be represented by a family of steep curves falling rapidly from very high values to zero in the narrow range *p*H 5–6, the curves for the more acidic proteins being displaced to the left of those for proteins with higher isoelectric points.

Owing to the extreme steepness of the curves, chromatographic behaviour is sharply dependent upon the *p*H and cation concentration of the buffers, and these must be accurately controlled. The best separation of the two hæmoglobins investigated here was obtained at *p*H 5·81 (sodium ion concentration 0·34), and under these conditions sheep fœtal carboxyhæmoglobin was unabsorbed ($R_F = 1$) and the bovine carboxyhæmoglobin had a value for R_F of 0·7.

Fig. 2*b* shows the chromatogram obtained from sheep fœtal hæmoglobin in citrate buffer of *p*H 5·8 at 25° C., using a column of finely ground '*IRC* 50', 5·0 cm. × 0·9 cm. The effluent from the column was collected in 0·2-ml. fractions and the hæmoglobin content of each fraction determined photometrically at 550 mμ. It was observed that as the hæmoglobin band progressed down the column it left behind a light deposit of coloured protein which appeared to be uniformly spread over the whole column. The carboxyhæmoglobin in the band was nevertheless eluted as a symmetrical peak without tailing. It was concluded that the material remaining on the column was probably denatured hæmoglobin (or represented some stage in the denaturation of the protein). It was found that the denatured protein could be eluted with concentrated sodium citrate buffer of *p*H 6·5 (sodium ion concentration 3·2), and peak *C* in Fig. 2*b* is the elution curve formed by this material.

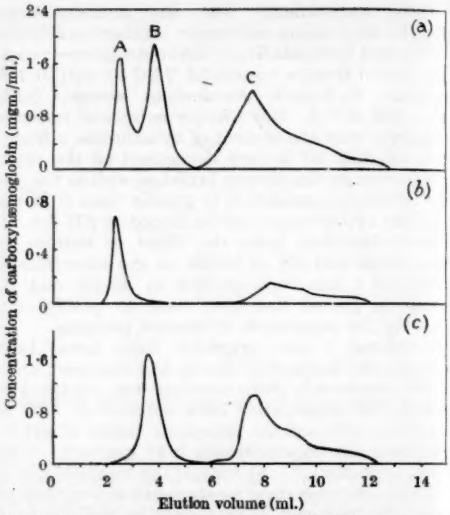

Fig. 2. Chromatograms of carboxyhæmoglobin using a column of '*IRC* 50', 5·0 cm. × 0·9 cm. Rate of flow, 0·5 ml./hr.; temperature, 25° C. Buffer: citrate *p*H 5·81, sodium ion concentration 0·34, changed to citrate *p*H 6·5, sodium concentration 3·2 after 1·2 ml.
(*a*) 5·7 mgm. of a mixture containing sheep fœtal carboxyhæmoglobin and bovine carboxyhæmoglobin. (*b*) 2·5 mgm. sheep fœtal carboxyhæmoglobin. (*c*) 3·1 mgm. bovine carboxyhæmoglobin

The chromatogram of bovine carboxyhæmoglobin is shown in Fig. 2*c*, and it will be observed that this protein also shows a second peak on changing the buffer to one of higher concentration and *p*H. The two carboxyhæmoglobins were then mixed and the elution carried out under the same conditions. Fig. 2*a* shows that the two proteins separated as symmetrical peaks (labelled *A* and *B*) and that the denatured material from both appeared as a third peak (*C*). Samples of pure protein obtained from peaks *A* and *B* appeared to contain no denatured material.

While the separation of the two hæmoglobins described above is satisfactory for some purposes, and could no doubt be improved somewhat by the use of a rather longer column, the yields of the pure components were low. It appears probable that, if the material in peak *C* has indeed been denatured by passage down the column, yields could be improved by working at lower temperatures. A study of the nature of the processes leading to changes in the protein on the surface of the resin is in progress, in the hope that extension of the procedure to the separation of other protein systems will be possible.

We wish to thank Dr. G. S. Adair for many helpful discussions during the course of this work. One of us (N. K. B.) is the holder of a Dafydd Lewis Trust Scholarship. The work forms part of the programme of the Food Investigation Organization of the Department of Scientific and Industrial Research.

[July 3.

[1] Tallan, H. H., and Stein, W. H., *J. Amer. Chem. Soc.*, **73**, 2976 (1951).
[2] Hirs, C. H. W., Stein, W. H., and Moore, S., *J. Amer. Chem. Soc.*, **73**, 1893 (1951).
[3] Paleus, S., and Neilands, J. B., *Acta Chem. Scand.*, **4**, 1024 (1950).
[4] Dixon, H. B. F., Moore, S., Stack-Dunne, M. P., and Young, F. G., *Nature*, **168**, 1044 (1951).
[5] Keilin, D., and Hartree, E. F., *Biochem. J.*, **39**, 289 (1945).
[6] Moore, S., and Stein, W. H., *J. Biol. Chem.*, **176**, 367 (1948).
[7] Hale, D. K., and Reichenberg, D., *Farad. Soc. Discuss.*, **7**, 82 (1949).
[8] Topp, N. E., and Pepper, K. W., *J. Chem. Soc.*, 3299 (1949).
[9] Adair, G. S. (private communication).
[10] Davis, B. D., and Cohn, E. J., *J. Amer. Chem. Soc.*, **61**, 2092 (1939).

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Action of Antibiotics on Avian Tubercle Bacilli studied with the Electron Microscope

THE method described by Brieger and Cosslett[1] of growing tubercle bacilli on the 'Formvar' film of a stainless steel electron microscope grid has been modified for use with liquid media. In this form the method has been found suitable for a study of the action of antibiotics upon growing tubercle bacilli. In order to prevent the fluid medium contaminating the inoculated surfaces, the grids are placed in contact with filter paper which rests on a cotton-wool support in a small dish 5 cm. in diameter and 2 cm. deep. The cotton-wool is kept moist by being thoroughly soaked in the medium. One dish can take up to twenty grids. The grids are inoculated with a drop of bacillary suspension using a fine platinum loop. If the drop does not stay on the surface of the grid, it is assumed that the holes in the 'Formvar' film are too large and the grid is discarded. The grids on which the drops remain are considered to be inoculated with similar numbers of bacilli. The dishes are incubated at 37·5° C. and grids removed at various intervals for inspection. Each grid is floated on sterile distilled water to remove any medium adhering to the lower surface, fixed by floating on 5 per cent formalin for 30 min., and washed again to remove any excess fixative. Throughout the procedure care is taken that the inoculated surface of the grid remains undisturbed. This is an essential condition for the study of variations in growth-rate.

A preliminary experiment was carried out to compare growth on the grids with growth directly on the medium. Grids inoculated with avian bacilli were placed on a Löwenstein plate and examined daily. At the same time, uninoculated grids were laid face downwards on the growth on a Löwenstein plate and impression prints taken on the 'Formvar' film. The comparison showed that the diffusion of the medium through the 'Formvar' film does not impair growth to any large extent. In fact, if inoculated grids are placed in dishes with Dubos medium, growth is usually so rapid that the squares of the grid are overgrown in two to three days even if the inoculation is made with a dilute suspension. With Dubos medium it is advisable to use small inocula and to examine the grids with a dry phase-contrast objective (× 40) before investigation in the electron microscope. Phase-contrast observation of grids can also be applied to the study of problems such as viability and growth-rate, especially the growth-rate in small inocula. Unfortunately, photographic recordings do not give very satisfactory results because the presence of the grid bars makes good phase-contrast difficult. However, some comparison can be made of the morphology and internal structure of the bacilli located in one square with phase-contrast and electron microscopy. Grids can also be stained in the normal way by carbol-fuchsin, after the examination by electron microscopy is completed. It is remarkable that the bacilli retain acid-fastness after exposure to the electron beam.

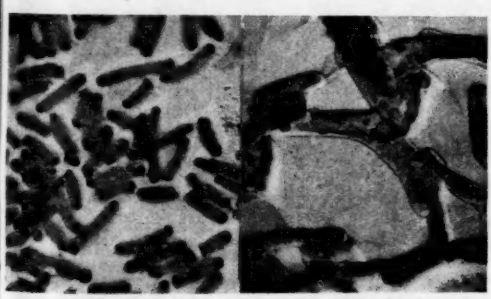

Fig. 1 Fig. 2

Fig. 1. Growth on normal Dubos medium. 3 days. Shadowed. × 6,200

Fig. 2. Growth on Dubos medium containing 100 μgm. of streptomycin per ml. 3 days. Shadowed. × 6,200

Fig. 3. Growth on Dubos medium containing 10 μgm. of streptomycin per ml. Mycelial strain. 5 days. Unshadowed. × 6,200

To study the action of streptomycin and *iso*nicotinic acid hydrazide ('Ditubin', Schering) two sets of dishes were prepared in which the Dubos medium contained 0, 10, 20 and 100 μgm. of antibiotic per ml. Under normal conditions, the short bipolar rods of the inoculum elongate up to seven times their original length in 24 hr. During this time, internal structure becomes apparent and shows that the filaments consist of a row of intracellular units and have two dense polar bodies. After three days the uniform bipolar filaments have broken down into individual rods (Fig. 1). The cultures containing streptomycin grow more slowly; the filaments initially formed differ from the normal ones in being much broader and showing less definite internal structure (Fig. 2). The bipolar densities which are still present in most filaments often increase in size and become distorted.

The mycelial tendencies present in some strains are encouraged by small doses of streptomycin, which also cause a broadening of the branches and an irregular arrangement of the dense bodies (Fig. 3). Higher concentrations of streptomycin (100 μgm. per ml.) arrest growth in the mycelial stage, and after seven days of incubation the filaments become very broad and some disintegrated mycelial branches are regularly seen.

In comparison, *iso*nicotinic acid hydrazide produces very different results. A dose of 10 μgm. per ml. has very little visible effect on the growth pattern. With doses of 20 μgm. per ml. and more, the rods of the inoculum do not elongate at first and seem to shrivel, lose their transparency, and appear as dense oval bodies with tapering ends. The further development depends upon the dose. With a dose of 20 μgm. per ml. normal filaments develop within three days side by side with the tapering rods (Fig. 4*a*). After

(*a*) (*b*)

Fig. 4. Growth on Dubos medium containing 20 μgm. of *iso*nicotinic acid hydrazide per ml. (*a*) 3 days. Shadowed. × 6,200; (*b*) 7 days. Shadowed. × 6,400

seven days the cultures seem to recover partially and a mass of filaments covers some squares of the grid (Fig. 4*b*). At higher concentrations of *iso*nicotinic acid hydrazide (100 μgm. per ml.) recovery does not begin until the seventh day of incubation and growth is greatly retarded.

Our observations only refer to the action of antibiotics on an avian strain which had lost much of its virulence during subculture. The results suggest that the technique described may be of value in assessing the action of antibiotics at a very early stage of development. They also show that streptomycin and *iso*nicotinic acid hydrazide attack the bacillus in different ways and cause different morphological changes. The initial inhibition by *iso*nicotinic acid hydrazide and the more delayed action of streptomycin suggest that a combination of the two antibiotics should give promising results. Clinicians have already used combined treatment with good effect. The method should also be useful in studying the genetical aspects of resistance to these substances.

We wish to thank Mr. H. Pearson for invaluable assistance in taking the electron micrographs.

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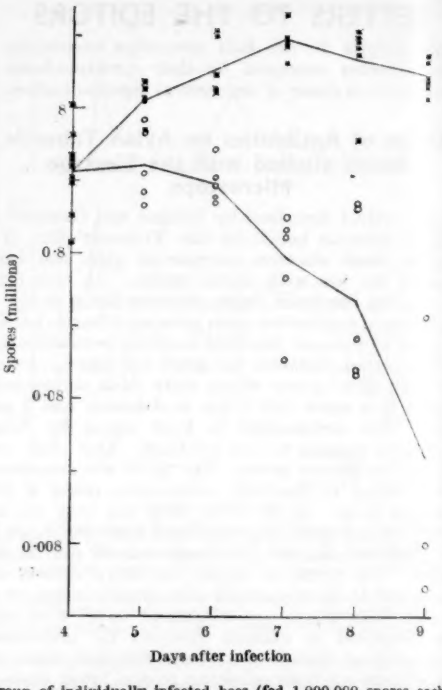
[1] Brieger, E. M., and Cosslett, V. E., *Nature*, **164**, 352 (1949).

Effect of Fumagillin upon *Nosema apis* (Zander)

A preliminary report by Katznelson and Jamieson[1] on the effect of the antibiotic fumagillin (derived from an *Aspergillus* culture designated *H*–3 [2]) upon the infection of the adult honey bee by the microsporidian *Nosema apis* indicated promising results. They suggested that the action of the drug was prophylactic in nature, killing the infective amœboid phase which is released from the spore into the ventricular lumen prior to its entry into the epithelial cells. This view was probably suggested by the results of McCowen *et al.*[3], which showed a depressant action of the drug upon the growth of bacteria-free cultures of *Endamœba hystolytica*.

I have fed measured numbers of spores of *Nosema apis* to individual bees and watched the progress of infection under various conditions of treatment by sampling bees daily and counting the ventricular content of spores by means of a hæmocytometer.



Group of individually infected bees (fed 1,000,000 spores each) divided four days after infection. One group (O—O—) fed freely on 6 mgm. fumagillin per 100 ml. of syrup; the other group (×—×—) continued on plain syrup.
6 mgm./100 ml. is a heavy dosage of drug. The effect becomes significantly less when about 1 mgm./100 ml. or less is fed

This technique has shown that the infection is most probably arrested or destroyed during its intracellular phase. If, for example, the infection was allowed to become well advanced and then the drug was fed in syrup, a practically instantaneous decline in infection took place (see graph). Also, bees fed with the drug during and after infection showed no greater decline in infection than those bees which were put on the drug two days after infection, by which time the intracellular phase of infection is well established and no amœboid forms remain within the ventricular lumen.

Sections of the ventriculus from recovering bees showed that spores became more restricted to those cells farthest away from the regenerative crypts or nidi. This suggests that the early vegetative forms of the parasite have been killed, or arrested in their development and re-infection of adjacent cells. The natural regeneration of cells from the crypts replaces those cells containing the later developed forms of the parasite.

Examination of sections and fresh material shows no histological difference between the renewed epithelium of the recovering bee and the epithelium of the healthy bee. The death-rate of treated bees was no different from that of healthy bees. Thus an intracellular protozoan parasite was destroyed in a striking fashion without any apparent damage to the structure and physiology of the host. However, relapses occurred even after the cessation of seventeen-day treatments; infection persists at the anterior end of the ventriculus, where the œsophageal invagination shields the epithelium.

Further experiments of this nature and with colonies of infected bees are in progress and the results will be published later. Thanks are due to the Upjohn Company of New York for supplies of fumagillin.

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[1] Katznelson, H., and Jamieson, C. A., *Science*, **115**, 70 (1952).
[2] Hanson, F. R., and Eble, E. J., *J. Bact.*, **58**, 527 (1949).
[3] McCowen, M. C., Callender, M. E., and Lawlis, J. F., *Science*, **113**, 202 (1951).

Heat Exchanges of a Muscle Model

Tendons immersed in a solution of mercury – potassium iodide contract; if held at constant length they exert tension, there being a reversible relation between tension and concentration of the reagent[1]. This system has been proposed as a model of the molecular mechanism of muscular contraction[2], and may be taken as typical of such models[3]. The reagent appears to act as a 'plasticizer', weakening attractions between protein molecules, and leaving them free to curl up under the influence of thermal agitation.

To demonstrate the energy relations of the system, a continuously acting machine was constructed, based on one described by Wiegand[4]. This consisted of a wheel with a heavy brass rim and twenty-four spokes made from tendons. The wheel was suspended in a narrow trough which was filled to the level of the axle with a concentrated (2 *M*) solution of mercury – potassium iodide, and above that with a very dilute solution. The lower spokes, which are immersed in the concentrated solution, contract, stretching the upper spokes and bringing the wheel out of balance so that it rotates half a turn. This brings the contracted spokes up into the dilute layer, in which they give up reagent and are extended in their turn by the contraction of the lower spokes. A light ratchet ensures that rotation is always in the same sense. The time for a complete rotation was about twenty minutes.

Over a complete cycle, the condition of the working substance, the spokes, is unchanged, and energy can only be derived from mixing of the solution. The heat of dilution of the mercury – potassium iodide solution was found to be negative, the addition of 50 ml. of a 2 *M* solution to an equal volume of water absorbing about 117 calories. This comparatively large absorption of heat indicates that dilution is accompanied by a net increase in potential energy, so that the only possible source of energy for mechanical work is the increase in the entropy of the solution on mixing.

The energy exchanges were followed in more detail by using shredded collagen (standard hide powder) instead of whole tendons; this permitted the use of large quantities, so that changes in temperature could be followed with a Beckmann thermometer. The heat of reaction of a molar solution of mercury – potassium iodide with swollen hide powder was found to be 1 cal./gm. dry weight, a low value which agrees with the observation that the reaction can be reversed by tension. By comparing natural hide powder with gelatin and with hide powder 'melted' by previous heating, a figure of 4 cal./gm. was obtained for the 'latent heat of fusion'. Both these values are the means of six determinations and are probably reliable to within about 1·5 cal./gm. The value for the latent heat of fusion is a minimum, but is perhaps nearer the mark than the figure of 16·8 cal./gm. found for tendon by Wöhlisch and de Rochement[5], which is based on a false estimate of the water content. Energy available from changes in crystalline arrangement thus seems to be small. The quantity of reagent absorbed was estimated by measuring the density of an *M*/4 solution of mercury – potassium iodide before and after allowing it to react with natural hide powder. From these measurements it appeared that, under the conditions used, about 3 gm. of mercury – potassium iodide are absorbed by 1 gm. dry weight of hide powder. This corresponds to 1 molecule of mercury – potassium iodide to 170 units of protein, or about 1 mol. per amino-acid.

We may now compare the model with Nature. It has been suggested that muscle operates on a similar cycle, with actomyosin as working substance and adenosine triphosphate as plasticizer, removal of plasticizer during the extension phase being by chemical decomposition rather than by elution. The first objection to this simple view concerns concentrations of reagent and amounts adsorbed. Adenosine triphosphate will cause contraction of extruded actomyosin filaments at concentrations[6] of the order of 10^{-3} *M*, and the amount adsorbed during contraction is of the order of 1 mol. per 100,000 units[7]. The least concentration of mercury – potassium iodide required to bring tendons to their 'fibre melting point' is about 0·2 *M*, at which the uptake is about 1 mol. per 170 units. No simple plasticizer could function at such dilutions as adenosine triphosphate does, but the mechanism in muscle is presumably an indirect one, involving some critical change of shape in the myosin by which it is rendered incapable of fitting on to the actin. A second difficulty is that, according to Weber[6], adenosine triphosphate does not bring about contraction of actomyosin filaments unless it is broken down at the same time; a filament of which the enzymatic activity has been abolished merely becomes plastic. Weber contrasts the activity of adenosine triphosphate in causing contraction with its effect as a plasticizer, but it appears from the model that the two differ only in degree, as tendon can be brought to a plastic state by the action of a concentration of mercury – potassium iodide just too low to cause contraction. The effect of the small amount of adenosine triphosphate adsorbed at any one time may be intensified by repeating the cycle, successive segments of the same molecule extending one another in the same way that one spoke extends another in the model. The rate of production of energy would then depend on the frequency of repetition of the cycle and on the amount of adsorbed plasticizer, which is in turn a function of the load.

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[1] Pryor, M. G. M., *Proc. Roy. Soc.*, B, **137**, 71 (1950).
[2] Pryor, M. G. M., "Progress in Biophysics", **1** (edit. Randall and Butler. London: Butterworth, 1950).
[3] Pryor, M. G. M., "Deformation and Flow in Biological Systems" (edit. Frey Wyssling. Amsterdam: North Holland Pub. Co., 1952).
[4] Wiegand, W. B., *Trans. Inst. Rubber Indust.*, **1**, 141 (1925).
[5] Wöhlisch, E., and du Mesnil de Rochement, R., *Z. Biol.*, **85**, 406 (1927).
[6] Weber, H. H., *Z. Elektrochem.*, **55**, 511 (1951).
[7] Mommaerts, W. F. H. M., *Biochim. Biophys. Acta*, **4**, 50 (1950).

A Coagulase-destroying Factor produced by Variants of *Staphylococcus aureus*

It has recently been shown[1] that rough variants of *Staphylococcus aureus* give high, and smooth variants low, yields of coagulase. The present communication shows that certain smooth variants produce a factor capable of destroying coagulase.

It was noticed that some colonies of the smooth variants were surrounded, on 'chocolate' agar, by a zone of discoloration and transparency. Cultures made from such colonies were more proteolytic (speed of liquefaction of gelatin, peptonization of milk), and yielded less coagulase than smooth variants with no action on chocolate agar. Some, in fact, did not clot plasma in 24–48 hr.; it is important, however, to mention that these were unstable and sooner or later gave rise to coagulase-positive cultures. From both the weakly positive and the apparently coagulase-negative, proteolytic variants a coagulase-destroying factor was isolated.

Many colonies showing a maximum zone of discoloration on chocolate agar were selected; each colony was suspended in 2 ml. of saline and inoculated on to a large agar slope in an 8-oz. flat bottle. After 18 hr. incubation at 37° C. each slope was washed with 4 ml. of meat-extract broth (*p*H 7·2); the suspensions were spun, the sediments discarded and the supernatants tested for plasma-clotting power. Those failing to cause clot in 24 hr. or with long clotting times (more than 6 hr.) generally contained the coagulase-destroying factor.

The coagulase-destroying activity of the supernatants was estimated in the following manner: mixtures of cell-free, heated coagulase were made with: (*a*) the supernatant, (*b*) the autoclaved supernatant and (*c*) meat-extract broth of a *p*H identical with that of the supernatant. All reagents contained 0·1 per cent merthiolate. Destruction of coagulase was revealed by a progressive increase of clotting time and decrease of titre of the mixture of coagulase with non-autoclaved supernatant (*a*); no destruction of coagulase was observed in the controls (*b*) and (*c*).

Variants showing the presence of the coagulase-destroying factor were found in all of ten strains examined, five strains giving extremely active variants. Thus the clotting power of a coagulase of a titre of 1 : 8,000 and a clotting time of 2 min. was completely abolished by incubation for 24 hr. with an equal volume of a very active supernatant. With potent preparations of the coagulase-destroying factor the destruction of coagulase at 37° C. became apparent 15–30 min. after mixing and progressed for 24–40 hr. The activity of the coagulase-destroying factor was most marked at a *p*H of 6·8–7·2; the activity was not strain specific. Cell-free coagulase-destroying factor was obtained by filtration through sintered glass and could be concentrated by cold (4° C.) precipitation with ten volumes of ethanol. The activity of the crude preparation was partly lost on heating for 10 min. at 70° C. and abolished by boiling for 30 min.; the ethanol-precipitated preparation was more heat-sensitive. The coagulase-destroying factor was inhibited by whole serum (man and horse), by serum globulins and by egg white.

Purely as a working hypothesis, it is assumed that the coagulase-destroying factor is a proteolytic enzyme. It is thought that along with the rough $\longleftrightarrow$ smooth variation in *Staphylococcus aureus* the occurrence of this factor may explain the irregularity of coagulase production *in vitro* observed by many workers. It seems also logical to believe that the coagulase-destroying factor is at least partly responsible for the low coagulase yields of smooth variants of this organism.

We are indebted to the Rankin Research Fund for a grant towards the expenses of this work.

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[1] Smith, D. D., Morrison, R. B., and Lominski, I., *J. Path. Bact.*, **64**, 567 (1952).

Noise from Aircraft at Supersonic Speeds

T. Gold, in *Nature* of November 8[1], has directed attention to the need for an explanation of the bangs that have been heard when aircraft in the vicinity have exceeded the speed of sound.

Gold develops his argument sufficiently far as to indicate when bangs may be expected. Briefly, an observer will experience a bang from every occasion on which the aircraft is travelling towards him at the speed of sound. This happens whenever $-\mathrm{d}r/\mathrm{d}t = c$, where r is the scalar distance of the aircraft from the observer, and c is the speed of sound. We see at once that triple and quadruple bangs will occur if there are three or four occasions respectively on which the aircraft is travelling towards the observer at sonic speed. Moreover, the aircraft itself does not have to pass through sonic speed more than twice to cause such multiple bangs: they can be caused by changes of course.

The occurrence of bangs having been explained, one must next consider their intensity. This will depend primarily upon $\mathrm{d}^2r/\mathrm{d}t^2$, varying inversely as the square root of this quantity if $\mathrm{d}^3r/\mathrm{d}t^3$ and higher derivatives can be neglected. It should be noted that $\mathrm{d}^2r/\mathrm{d}t^2$ is not the acceleration of the aircraft away from the observer, which is $\mathrm{d}^2r/\mathrm{d}t^2 - r(\mathrm{d}\theta/\mathrm{d}t)^2$. For $\mathrm{d}^2r/\mathrm{d}t^2$ small, the intensity will depend also upon $\mathrm{d}^3r/\mathrm{d}t^3$. A flight path such that $\mathrm{d}r/\mathrm{d}t$ is constant and equal to $-c$ is of interest, as $\mathrm{d}^2r/\mathrm{d}t^2$, $\mathrm{d}^3r/\mathrm{d}t^3$ and all higher derivatives are zero, and a bang of enhanced intensity would be expected. Such a flight path is the equiangular spiral of angle equal to the Mach angle, $r = r_0 \exp\{-\theta/\sqrt{(M^2-1)}\}$, where M is the Mach number. It degenerates for a Mach number of unity into a straight line, and for a Mach number of infinity into a circle. The former is of interest in indicating that disturbances of enhanced intensity are to be expected from periods of steady flight at a Mach number of unity, although they will be localized, and will be experienced only by observers in the direct line of flight.

The final point that needs clarification is the cause of the bangs. Three possible sources of the disturbances can be put forward, the disturbances in all cases being propagated in the same manner, as outlined by Gold. First, there are the aerodynamic disturbances that would result from flight through an inviscid fluid: these will depend upon the size and shape of the aircraft. Secondly, there are the aerodynamic disturbances due to the turbulence created by the boundary layers, by regions of flow

separation and by the wake. Finally, there are the acoustic disturbances which arise from the fact that the aircraft, through the medium of its engines, is a source of noise. Simple estimates show that the enhancement of the noise of the aircraft in a typical case falls very far short of the intensity of the pressure disturbance associated with the bang (about 1 lb./ft.²). Equally, although it is more difficult to show, it is not expected that the enhancement of the disturbances due to turbulence could be sufficient to explain the intensity of the bangs. On the other hand, calculations have been made of the disturbances to be expected from flight through an inviscid fluid, and these yield pressure disturbances that are of the same order as those that have been experienced.

Thus far we have explained the occurrence of the bangs, and the intensity of the peak pressure disturbance to be expected. What still needs clarification is the acoustic 'character' of the bang. In particular, do the disturbances due to engine noise and due to turbulence make a significant contribution to what one actually hears ?

I am indebted to the Chief Scientist, Ministry of Supply, for permission to publish this communication, but the views expressed are my own.

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[1] *Nature*, **170**, 808 (1952).

The impression exists that the double bang made by supersonic flight is mysterious. It would be well if those who support this view would bring forward the arguments that show that the exact and straightforward account of the bangs given by T. Gold[1] is wrong. The following circumstances have made the subject seem mysterious; but, in fact, none of them is a real objection to the straightforward account.

(*a*) At the recent Farnborough display, the black *D.H.* 110 aircraft gave a triple bang on at least one occasion. But we should in general expect multiple bangs if an aircraft were to change course slightly in its supersonic flight, for then there would be two solutions of the equation $-\mathrm{d}r/\mathrm{d}t = c$, for each straight portion of the aircraft's path, where r is the scalar distance between aircraft and observer. When three bangs are heard, it is likely that there are really four, of which two happen to coincide. It must be remembered that these bangs are so close as scarcely to be heard separately.

(*b*) The bangs are often said to be produced as the aircraft 'pierces the sound barrier' at either end of its supersonic flight. This is inconsistent with Gold's account, according to which at every given supersonic speed there is a direction making a definite angle with the direction of flight along which the bang will be propagated. Now the first account cannot be correct, because it means that the very loud bang heard at all points on the ground will have been produced at one point in the track of the aircraft. Such a dissipation of energy would be of an altogether greater order of magnitude than that at other points, and the aircraft could not accelerate to greater speeds.

(*c*) The objection that shock waves and sound waves are different in nature is not relevant to this discussion, because we need consider only regions outside a certain closed surface surrounding the aircraft, at all points of which the particle displacement due to sound or shock waves is small compared with their wave-length. Yet this closed surface can be effectively at a point as far as listeners on the ground are concerned.

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Nov. 19.

[1] *Nature*, **170**, 808 (1952).

The acoustic phenomena accompanying the dive of an aircraft to attain supersonic speed appear to be adequately explained by the Huyghens wavelet construction. The case of a body moving at a uniform supersonic speed V in a straight path, in a uniform atmosphere, is well known. Circular wavelets, expanding with the velocity of sound c, are centred on successive positions of the body at chosen time intervals. The envelope of the wavelets representing a shock wave front is a cone with the line of flight as axis and half-angle α given by

$$\sin\alpha = c/V = 1/M,$$

where M is the Mach number.

In the case of a body moving in a uniform atmosphere, in a straight path, at a speed which increases and then decreases through the speed of sound, the shock wave departs radically from the single conical surface and becomes a meniscus symmetrical about the line of flight, with two surfaces. In the example shown in Fig. 1, the duration of supersonic flight is 16 sec. and the Mach numbers are shown at the positions of the body at second intervals.

In the case of a body moving in a uniform atmosphere, at a uniform speed, in a curved path, the shock wave becomes a distorted meniscus. The section in the plane of the flight path is similar in general outline to that shown in Fig. 2.

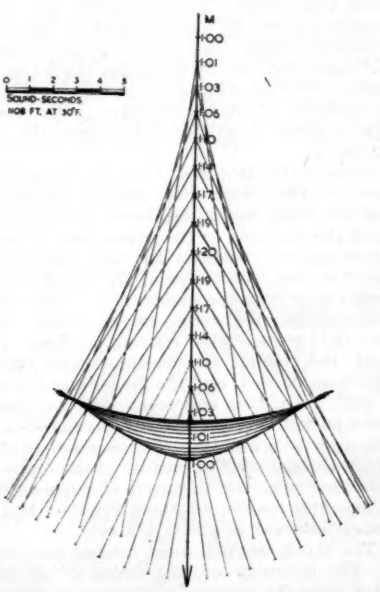

Fig. 1. Shock wave formed by a body moving in a straight line at a speed which increases and then decreases through the speed of sound

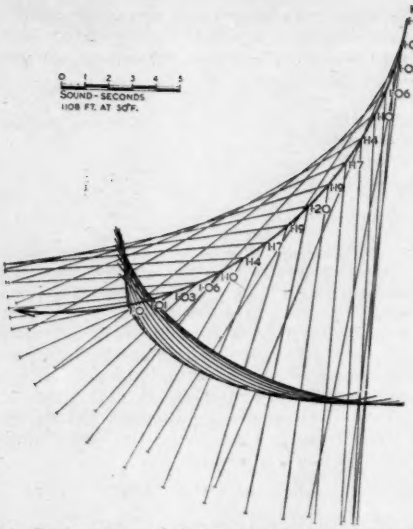

Fig. 2. Shock wave formed by a body moving in a circular path at a speed which increases and then decreases through the speed of sound

In the case of a body moving in a uniform atmosphere, in a curved path, at a speed which increases and then decreases through the speed of sound, the shock wave is again a distorted meniscus. The section in the plane of the flight path is represented in Fig. 2 for the particular case in which the flight path is the arc of a vertical circle with radius 15 sound-seconds and the duration of supersonic flight is 16 sec., the assumed Mach numbers at second intervals during this period being shown against the positions of the body. Sound rays are drawn from the point of origin of each wavelet perpendicular to the shock wave front. To do this the ray is drawn at an angle α given by $\sin \alpha = 1/M$, to the tangent to the circular flight path at the point of origin of the particular wavelet, M being the Mach number at that point. The separation of the rays is a measure of the intensity of the shock wave; the closer the rays for a given length of flight path the greater the intensity.

The outstanding features of the shock wave are as follows. (1) The shock wave has two surfaces, the forward one being due to the lower part of the flight path and the rear one to the upper part of the path. The time interval between the two surfaces varies from zero at the outer edge of the shock wave to a maximum at or near the middle of it. The maximum interval and also the extent of the shock wave are greater the greater the maximum Mach number attained, the smaller the acceleration to that Mach number from $M = 1$, and the flatter the curve of the flight path. Uniform supersonic speed in a straight path is a particular case in which acceleration is zero and the interval is infinite. In the example of Fig. 2, for which the radius of curvature of the flight path is 15 sound-seconds, the duration of supersonic flight is 16 sec. and maximum Mach number is 1·2, the maximum interval is about 1·2 sec.

(2) The shock wave is most intense near its outer edge. The intensity on the inside of the curve of the dive, near the plane of the curve, is greater than on the outside of the curve and is maintained to greater distances after the Mach number has fallen below 1 because the divergence of the rays is comparatively small. Intensity is increased by increasing the acceleration to maximum Mach number from $M = 1$ and by diving in a path of smaller radius of curvature.

The assumptions of a uniform atmosphere and a dive in a vertical circular arc are simplifications of the actual case of an aircraft diving to attain supersonic speed, but the features listed above should be fairly representative of the acoustic effects to be expected.

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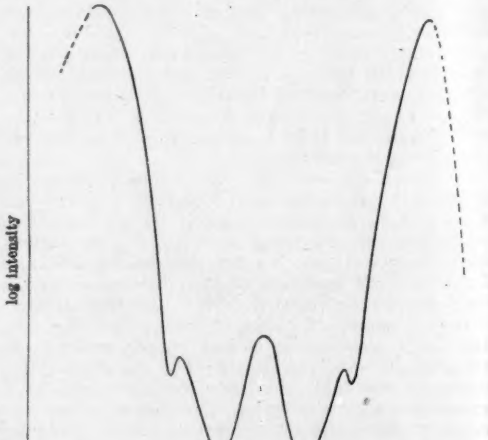
Piezo-electric Oscillations of Quartz Plates at Even and Half-odd Harmonics

It is well known that a piezo-electric quartz plate can be excited into strong oscillations at its fundamental frequency, mainly determined by its thickness, or at any of its odd multiples, the even multiples being ruled out on theoretical considerations[1]. Parthasarathy[2] first observed that a quartz plate can vibrate at its 5/2 and 7/2 harmonics. Afterwards, Parthasarathy, Pande and Pancholy[3] showed that an X-cut quartz plate could also be made to oscillate, though with a lower intensity, at its even harmonics and such frequencies as $\frac{1}{2}$, 3/2, 5/2, etc., of its fundamentals. This observation was later confirmed by Tsien and Chu[4] and Özdogan[5]. The former also reported that, besides the even and half of odd multiples of the fundamental frequency, the plate would oscillate continuously, though with less intensity, at any intermediate frequency.

It has been suggested[1,6] that this effect might be due to one or more of the following causes: (*a*) twinning or other defect in the quartz plate; (*b*) inhomogeneous electric field; (*c*) uneven plating; (*d*) feed-back to the oscillator. Experiments were



recently undertaken with the view of eliminating these possibilities. A number of quartz plates of different dimensions, obtained from well-known American manufacturers of frequency-control crystals, were plated fairly uniformly with silver, aluminium and copper by different methods such as electrochemical deposition, metal evaporation in vacuum, electroplating, etc. These plates were excited by the output of a master-oscillator power-amplifier with a buffer amplifier in between the oscillator and the crystal. The crystal was put in a liquid medium and the diffraction pattern obtained by the usual Debye–Sears method. It was noticed that the crystal could be made to oscillate at any frequency, though the intensities varied at different frequencies. The relative intensities of the diffraction lines revealed that, for the same radio-frequency feed, the crystals oscillated vigorously at their odd harmonics and less vigorously at the even and half of odd multiples. The intensities of the diffraction lines showed peaks in these regions. In going from one odd harmonic to another, the amplitude of oscillations as indicated by the diffraction lines undergoes variations as shown in the accompanying graph.

The results confirm the earlier observations that a piezo-electric quartz plate has preferred modes of oscillation at the even and half of odd multiples of its fundamental frequency in addition to the odd harmonics.

A detailed paper is being published elsewhere.

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[1] Bergmann, L., "Der Ultraschall", 61 (Hirzel Verlag, Zurich, 1949).
[2] Parthasarathy, S., *Proc. Ind. Acad. Sci.*, A, **3**, 297 (1936).
[3] Parthasarathy, S., Pande, A., and Pancholy, M., *J. Sci. Ind. Res.*, **2**, 295 (1944).
[4] Tsien, L. C., and Chu, H. C., *Nature*, **156**, 424 (1945).
[5] Özdogan, I., Revue de la Faculté des Sciences de l'Université d'Istambul, A., **12** (2), 53 (1947).
[6] Cady, W. G., "Piezoelectricity", 369 (1946).

Damping of Turbulence by a Magnetic Field

In experiments which I carried out in the summer of 1951, mercury flowing in a long narrow rectangular channel at a Reynolds number R entered a region of constant transverse magnetic field H. The pressure gradient was measured downstream of any entrance effects.

For a given fluid, the pressure gradient can be shown to be a function of the dimensionless quantities R and M, where $M = \mu Ha\sqrt{\sigma/\eta}$, and η is the coefficient of viscosity. Hartmann[1] gives the theoretical form of this function for the case of laminar flow. Lundquist[2] gives theoretical reasons for expecting the critical value of R to vary linearly with M.

My experiments covered the range $0 < M < 130$, $10^4 < R < 1{\cdot}2 \times 10^5$. With $M > 1{,}000$ R, the pressure gradient agreed with Hartmann's laminar flow solution. With $M/R < 1{,}000$, the pressure gradient was larger than that predicted by the laminar flow solution. This suggests that turbulence is present, and confirms Lundquist's predictions.

The action of the magnetic field in damping turbulence has been studied. It appears that this damping is progressive with increasing field, as surmised by Lundquist. There was no evidence for the creation of turbulence near the walls due to the high rates of shear produced by the 'Hartmann effect', as suggested by Lehnert[3].

I wish to thank the Director of the Atomic Energy Research Establishment, Harwell, for permission to publish this letter.

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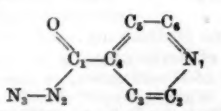
July 31.

[1] Hartmann, J., *Danske Videnskabernes Selskab.*, **15**, 6 (1937).
[2] Lundquist, S., *Ark. Fys.*, **5**, 15 (1952).
[3] Lehnert, B., *Ark. Fys.*, **5**, 5 (1952).

Crystal Structure of *iso*Nicotinic Acid Hydrazide

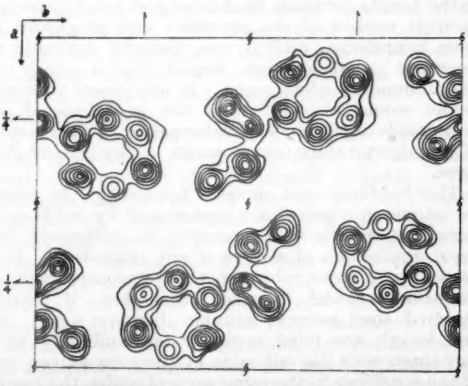
As part of a programme of X-ray diffraction studies of biologically important compounds, the crystal structure of *iso*nicotinic acid hydrazide ('Nydrazid') is being determined.

The lattice parameters and space group were determined from Weissenberg photographs about the a- and c-axes. The unit cell is orthorhombic, space group $P2_12_12_1$, with $a = 11{\cdot}33$ A.; $b = 14{\cdot}74$ A.; $c = 3{\cdot}84$ A. There are four molecules in the unit cell; calculated density 1·42 gm.cm.$^{-3}$; observed, 1·41 gm.cm.$^{-3}$.



Structural formula for *iso*nicotinic acid hydrazide

The intensities for $\{hk0\}$ were put on an 'absolute' basis[1], and an unsuccessful attempt was made to determine a set of signs for the larger F's[2]. A Patterson projection on (001) showed the orientation of the ring, and the approximate position of the molecule was obvious from the magnitudes of F_{110}, F_{120}, F_{200} and F_{210}. It was, however, immediately apparent from F_{200} and F_{210} that the 'absolute' intensities were high by a factor of *c.* 3. Thus the expected root-mean-square unitary structure factor is 0·16; neglecting a relatively small temperature factor, observed value is 0·04. Furthermore, calculation of the ratio $(\overline{|F|})^2/\overline{I}$ for various intervals $0{\cdot}256 < \sin\theta < 0{\cdot}745$ showed a marked decrease in value for $0{\cdot}50 < \sin\theta$, the weighted average value being



Projection on (001) for *iso*nicotinic acid hydrazide. Contours are drawn at intervals of 1 *e* A.$^{-2}$, contours below 2 *e* A.$^{-2}$ omitted

0·50 [2]. This is to be compared with a value of 0·637 to be expected for a projection which is centrosymmetrical[4].

Electron densities were calculated at units of $a/30$ and $b/60$, using Patterson–Tunell strips. Successive F syntheses refined slowly. The seventh synthesis with seventy terms based on intensities estimated by eye is shown in the accompanying diagram.

The approximate x- and y-co-ordinates based on this synthesis are given in the table.

Approximate x- and y-Co-ordinates

	x	y
C_1	0·256	0·505
C_2	0·224	0·742
C_3	0·271	0·666
C_4	0·212	0·588
C_5	0·091	0·601
C_6	0·045	0·680
N_1	0·107	0·752
N_2	0·377	0·490
N_3	0·422	0·410
O	0·200	0·445

Integrated intensity data are being used in refinement of the (001) projection and the determination of the z-co-ordinates. A full account of this work will appear at a later date.

I wish to thank E. K. Squibb and Sons for the sample of crystalline 'Nydrazid' used in this study, and Dr. Wayne Chen, who performed most of the numerical work.

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Aug. 6.

[1] Wilson, A. J. C., *Nature*, **150**, 152 (1942).
[2] Zachariasen, W. H., *Acta Crystall.*, **5**, 68 (1952).
[3] Howells, E. R., Phillips, D. C., and Rogers, R., *Acta Crystall.*, **3**, 210 (1950).
[4] Wilson, A. J. C., *Research*, **2**, 246 (1949).

A Dislocation Model for the Study of Boundary Phenomena and Deformation in Metals

In an earlier communication[1], an account was given of an experimental examination of the behaviour of the crystal boundaries in aluminium and its alloys at temperatures near the melting point. In an extension of this work, some consideration was given to the results obtained by Achter and Smoluchowski[2] in their studies of the structure and properties of grain boundaries, and it was thought desirable to construct a dislocation model for a study of grain-boundary phenomena. It was hoped that this model would also prove of use in a related investigation of the mode of deformation of the crystals of a polycrystalline mass under a rapidly applied force.

The bubble model devised by Bragg[3], in which the atoms in a metal are represented by bubbles, is somewhat fragile and unsuited to withstand the rapid application of a force of any magnitude. In a search for a more robust method of construction of an atomic model, it was found that, if several hundred steel rods of suitable diameter ($\frac{1}{16}$–$\frac{1}{8}$ in.) and length are piled together longitudinally in a container, with the cut ends of the rods at one end of the container in the same vertical plane, the resulting pattern of the cut ends of the rods is similar to that of the bubbles in the bubble model. Fig. 1 shows that the rod model provides a useful schematic illustration of the atomic arrangement in a polycrystalline metal. The regions of atomic disorder at a crystal boundary are well defined. Single dislocations and lines of dislocation within the crystals are also apparent, one such line being shown on a larger scale in Fig. 2.

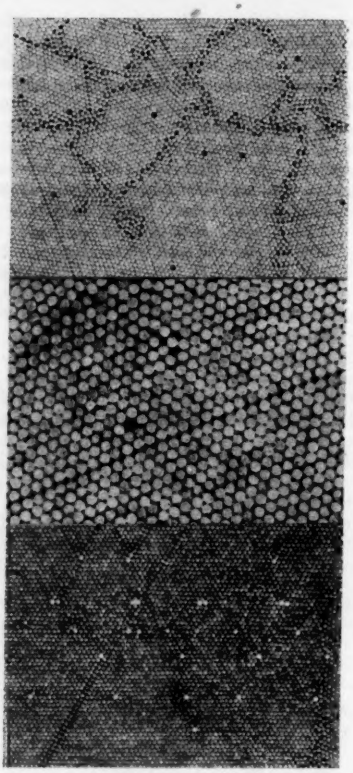

Fig. 1

Fig. 2

Fig. 3

Fig. 1. Atomic arrangement in a polycrystalline metal as represented by the rod model

Fig. 2. Single dislocations and line of dislocation in a crystal illustrated by the rod model (magnification greater than that of Fig. 1)

Fig. 3. Effect of introduction of atoms of larger size than average (white spots) into an atomic structure as represented by rod model

The rod model is robust and well suited for demonstration purposes. The effect of introducing atoms of large diameter into an atomic structure may be simulated by introducing rods of larger diameter than the average into the container (Fig. 3). If the container is made suitably flexible by hinging the sides or making them of more flexible material, the rod model may be used for observing the effect on a polycrystalline structure of the rapid application of loads of appreciable magnitude.

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[1] Pumphrey, W. I., and Lyons, J. V., *Nature*, **163**, 960 (1949).
[2] Achter, M. R., and Smoluchowski, R., *J. App. Phys.*, **22**, 1260 (1951).
[3] Bragg, W. L., *J. Sci. Instr.*, **19**, 148 (1942).

Height of the Potential Barrier in Barrier Layer Cells

Measurements of the zero resistance of a number of barrier-layer cells[1] over a wide range of temperatures have shown that the theoretical expression :

$$R_0 = AT \exp(\varphi/T), \qquad (1)$$

where A and φ are regarded as constants, is not obeyed over the whole range of temperatures. The power of T appearing outside the exponential in equation (1) depends on the assumptions made in the theoretical treatment ; values ranging from $+ 3/2$ to $- 1/4$ [2-5] have been obtained, but these do not significantly alter the shape of the curve. Accordingly, the value of unity has been used in this work. It is the purpose of this communication to put forward a possible explanation of the observed departure from equation (1).

In the case of selenium rectifiers, the existence of weak spots has been postulated to explain breakdown phenomena[2], and in germanium the multicontact theory[5] has been proposed to explain the forward characteristics of point-contact diodes. By a simple mathematical analysis of these postulates, it is possible to account for the zero resistance measurements. The barrier layer is considered as being made up of a number of elements in parallel, to each of which equation (1) applies. The parameter φ is assumed to have a normal distribution among the elements about a mean value $\bar{\varphi}$ with standard deviation S. Then it is easy to show that, for the whole cell,

$$\frac{R_0}{T} = \frac{2A}{N(1 + \operatorname{erf} x)} \exp\left[\frac{\bar{\varphi}}{T} - \frac{S^2}{2T^2}\right], \qquad (2)$$

where N is the number of elements, and

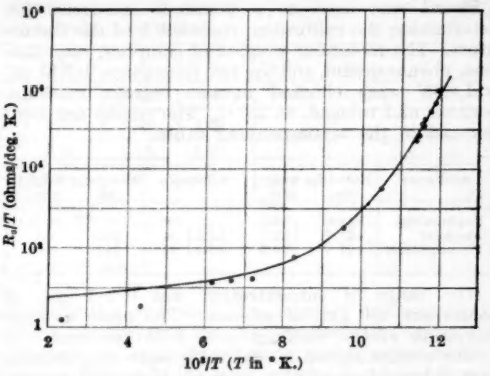
$$x = \frac{1}{S\sqrt{2}}\left(\varphi - \frac{S^2}{T}\right).$$

Equation (2) has been fitted to the results for a selenium rectifier, and the theoretical curve and experimental points are shown in the accompanying graph. A similar fit has been obtained with a commercial selenium photocell and germanium and silicon point diodes. Values of $\bar{\varphi}$ and S obtained by fitting equation (2) to the experimental results are shown in the table.

	$\bar{\varphi}$ (eV.)	S (eV.)
Selenium rectifier	0·69	0·09
Selenium photocell	0·86	0·12
Germanium rectifier	1·13	0·13
Silicon rectifier	0·47	0·07

It is clear from the experimental results that equation (1) cannot be used as a reliable method for the determination of φ, but $\bar{\varphi}$ and S obtained from equation (2) will give some indication of the uniformity of the barrier layer.

The above calculations can be modified by allowing for an upper and lower limit for the distribution of φ ; the shape of the curve is found to be sensitive to the lower, but very insensitive to the upper, limit. This is in agreement with the multicontact theory, where it is shown that it is the low-value tail of the distribution which is of primary importance. The upper limit may be less than $\bar{\varphi}$, so that the occurrence of $\bar{\varphi}$ greater than the width of the energy gap in the semiconductor need not imply that the individual barrier heights exceed this value ($\bar{\varphi}$ for germanium, 1·13 eV.; width of energy gap, 0·72 eV.). Detailed calculations of this sort were not considered worth while, as the data so far available do not justify the inclusion of yet another parameter.



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[1] Billig, E., and Ridout, M. S., *Nature*, **167**, 1028 (1951).
[2] Billig, E., and Landsberg, P. T., *Proc. Phys. Soc.*, A, **63**, 101 (1950).
[3] Billig, E., *Proc. Roy. Soc.*, A, **207**, 156 (1951).
[4] Landsberg, P. T., *Proc. Phys. Soc.*, B, **65**, 397 (1952).
[5] Johnson, V. A., Smith, R. N., and Yearian, H. J., *J. App. Phys.*, **21**, 283 (1950).

Molecular Weight Determination by Thermistors

A THERMISTOR is a resistance body which has a high negative temperature coefficient of resistance, and is a valuable circuit element with a large variety of applications. Thermistors can be used as sensitive thermometers in cryoscopic measurements[1] and also in place of thermocouples for measuring the lowering of vapour pressure of aqueous colloidal solutions[2]. At a condition of steady state, the droplets of solution and solvent deposited on the tips of the thermistors have a constant difference in temperature which can be measured as a difference of resistance in an A.C. bridge circuit. The construction and operation of a simple A.C. thermistor bridge, used for measuring the osmotic activities of aqueous solutions, has been described by McGee and Iyengar (submitted for publication elsewhere).

A pair of matched thermistors can also serve as a sensitive element for determination of molecular weights of compounds in organic solvents. The resistance differential ΔR set up per unit molal difference in concentration between the drops of solvent and solution ($k = \Delta R/m$) is generally much higher for organic solvents than for water ; for example, $k = 12{\cdot}1$ ohms/mol. for water and $40{\cdot}1$ ohms/mol. for toluene in the case of a pair of Western Electric thermistors (Type 14*B*, resistance about 2,000 ohms at 25°). Thus, organic solvents increase the sensitivity of measuring the small difference of vapour pressure between the drops of solution and solvents.

Benzil was used as a standard substance for determining the calibration constant k of the thermistors. The molecular weights of camphor, naphthalene, phenanthrene, and the two detergents 'BRIJ 30' and '35' were checked in two organic solvents, benzene and toluene, at 25° C. The results are summarized in the accompanying table.

Substance	Molecular weight obs.	calc.	Substance	Molecular weight obs.	calc.
Naphthalene	128·0	128·2			
Camphor	151·9	152·2	'BRIJ 30'	435	—
Phenanthrene	177·6	178·2	'BRIJ 35'	747	—

The range of concentration was 0·5–7 gm. of solute per 100 gm. of solvent. The mean average deviation of the readings is ± 0·25 per cent.

The results shown in the table were reproducible and independent of the concentrations and solvent used, within the limits of experimental error. The thermistor has been found to be extremely sensitive, and has the further advantages of being rapid in its operation and free from the spurious electrical effects that might be encountered within the D.C. thermocouple method of Hill-Baldes[3]. It is also seen to be far more accurate than the chemical boiling-point and vapour-pressure methods, thus permitting the study of very dilute solutions.

The Beckmann freezing-point method is limited to low temperatures, where the solubility of many substances is inadequate. However, the most important advantage of the thermistor technique over the usual Beckmann freezing-point method is the wide range of temperatures and solvents which can be employed in the measurements. Besides being far more accurate than the Beckmann methods, only a few drops of solution are required for the measurement.

With the present set of thermistors, the limit of molecular weight measurement is roughly 2,000 in water and 5,000 in benzene. As soon as more-sensitive thermistors become available, the method can be extended to compounds of higher molecular weight.

I wish to express my thanks to Prof. J. W. McBain, Dr. S. S. Marsden and Dr. B. R. Y. Iyengar for their suggestions and interest in the work.

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[1] Zeffert, B. M., and Hormats, S., *Anal. Chem.*, **21**, 1420 (1949).
[2] Brady, A. P., Huff, H., and McBain, J. W., *J. Phys. Coll. Chem.*, **55**, 304 (1951).
[3] Taylor, G. B., and Hall, M. B., *Anal. Chem.*, **23**, 945 (1951).

The Laws of Friction

The laws of static friction are usually described as: (1) $F = \mu R$, which governs the relation between limiting frictional force F and normal reaction R; and (2) the coefficient of friction μ is independent of the apparent area of contact.

Exceptions to law (1) are now well established, and in the field of fibre friction have been known for some time. In these cases the friction is governed by an expression of the form $F = aR^n$, where n has values for different materials ranging from 0·67 to 1·0, the value for metals. Thus Bowden and Young[1] obtain $n = 0·8$ for diamond, Lincoln[2] 0·67 for nylon and Howell and Mazur[3] 0·96 for cellulose acetate, 0·91 for viscose rayon, 0·90 and 0·80 for undrawn and drawn nylon respectively. This form of the frictional relation is more general than law (1), and it is the purpose of this note to point out certain consequences which arise from it.

(1) Amontons's law $F = \mu R$ represents the special case of $n = 1$.

(2) The frictional force F now depends upon the apparent area, and only in the particular case of $n = 1$ is it independent. Consequently, the two laws as such are not independent, but law (2) is a natural consequence of law (1).

(3) If the effect of roughening a surface is to produce valleys large compared with the distance between surface asperities, then the area available for real contact is reduced with a consequent reduction in the frictional force.

(4) In the important case of friction of a string around a pin or cylinder, the tension relation $T = T_0 \exp \mu\theta$ is derived on the assumption $F = \mu R$. If the general expression $F = aR^n$ is used in the analysis, the relation becomes

$$\left(\frac{T}{T_0}\right)^{(1-n)} = 1 + (1 - n) \cdot a \left(\frac{\rho}{T_0}\right)^{(1-n)} \theta ;$$

or, in the limit as n approaches unity,

$$T = T_0 \exp a \left(\frac{\rho}{T_0}\right)^{(1-n)} \theta,$$

where ρ is the radius of the cylinder, which is not involved in the usual treatment. The data on the tensions of wool fibres given by Martin and Mittelman[4] have been examined and found to conform to this expression.

(5) The coefficient a in $F = aR^n$ is not dimensionless except when $n = 1$, but normally has dimensions $[\text{force}]^{1-n}$.

Again, in the case of the cylinder, since F and R in the analysis refer to unit length, the dimensions are $[\text{force/length}]^{1-n}$.

A full account of this work, which forms part of a programme of fundamental research of the British Rayon Research Association, will be given elsewhere.

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[1] Bowden, F. P., and Young, J. E., *Proc. Roy. Soc.*, A, **208**, 444 (1951).
[2] Lincoln, B. (private communication).
[3] Howell, H. G., and Mazur, J. (forthcoming publication).
[4] Martin, A. J. P., and Mittelman, R., *J. Text. Inst.*, **37**, T 269 (1946).

A Method of determining the Electrical Resistance of Fibre Bundles

Some years ago, one of us[1] showed that the quantity of static electricity developed on textiles during, for example, the carding operation, could be explained in terms of the electrical leak through the fibre; but the resistance measurements made at that time were limited to the order of 10^{11} ohms by the electric leak of the supporting frame.

We have recently devised a method which enables such resistance measurements to be made up to the order of 10^{17} ohms, and which avoids this leak by eliminating the supporting frame. In this method the bundle of fibres or sliver is hung vertically from a metal support to which is applied a voltage of the order of 5 kV., and the total charge resident on the fibre after a known period of application of voltage is measured by transferring the bundle to a Faraday cylinder.

SPECIMEN : COTTON

Applied voltage (V) = 5 kV. Final charge (Q_∞) = 0·0285 μC.

t (hr.)	0	0·4	0·6	0·75	0·9	1·0	1·3	1·5	1·8	2·85	3·1	3·5
Q (μC.)	0	0·014	0·016$_5$	0·019	0·020	0·021	0·023	0·02$_7$	0·025$_5$	0·028$_0$	0·028$_5$	0·028$_5$
Q/Q_∞	0	0·49	0·58	0·66$_5$	0·70$_5$	0·73$_5$	0·81	0·88	0·89			
t/CRL^2	0	0·19	0·27	0·36$_5$	0·42	0·46	0·59	0·75$_5$	0·82			
CRL^2(hr.)		2·1	2·2	2·1	2·1	2·2	2·2	2·0	2·2			

Average CRL^2(hr.) = 2·1 $\quad CL = \frac{Q_\infty}{V} = 5{\cdot}7\ \mu\mu$F.

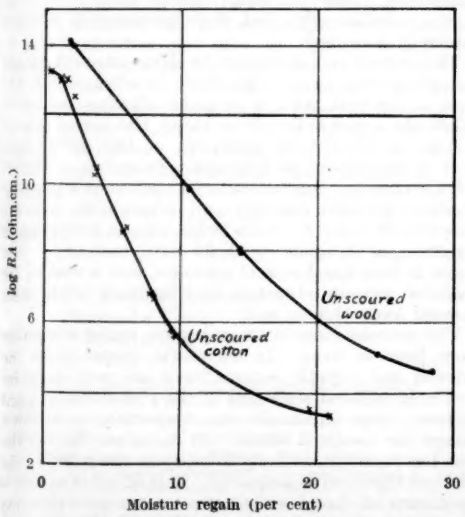
$$RL = \frac{2{\cdot}1 \times 36 \times 10^{14}}{5{\cdot}7} = 1{\cdot}3 \times 10^{15} \text{ ohms.}$$

The equation for the voltage at any point in the bundle is identical with that describing the flow of heat in a conducting rod, and a convenient solution is given by Carslaw and Jaeger[2]. Integrating their expression, a graph is obtained between the ratio of total charge to the equilibrium charge and the product t/CRL^2 (where t is time in sec., R is resistance per unit length in ohms, C is capacitance per unit length in farads and L is length of the sample). CL is, of course, equal to the final charge on the sample divided by the applied voltage. A set of experimental results using this method is shown in the table.

In our experiments the samples are suspended axially in a metal pot 45 cm. in diameter, and this vessel has passed through it a current of air at controlled relative humidity. Some typical curves connecting moisture regain and electrical resistance are shown in the accompanying graph.

At resistances of the order of 10^{12} ohms, the times involved become too small for convenient measurement; but at this level the normal condenser-discharge method, using a capacitance of the order of 200 pF., can be used if the lower end of the fibre bundle is also bound with a fine wire. The new method gives results consistent with those by the conventional condenser-discharge method at this level.

The rate of charge method can be applied to single textile fibres. The method we have found most convenient is to secure a $\frac{3}{32}$-in. bearing ball to the lower end of the fibre, which is then charged by applying voltage to the other end. The relevant mathematical formula is again provided by Carslaw and Jaeger[2].



Resistance regain for card slivers

Preliminary experiments show that the resistance of single fibres is of the same order as, but lower than, that calculated from the experiments made with fibre bundles or slivers. It is hoped that these differences will enable the effect of lateral contact resistance in a sliver of staple fibre to be evaluated.

It is hoped to publish a detailed account of these experiments in the near future.

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[1] Keggin, Morris, and Yuill, *J. Text. Inst.*, **40**, T702 (1949).
[2] Carslaw and Jaeger, "Conduction of Heat in Solids", p. 83, equat. 2 (Oxf. Univ. Press, 1947).
[3] Carslaw and Jaeger, "Conduction of Heat in Solids", p. 107, equat. 21 (Oxf. Univ. Press, 1947).

Molecular Configuration of Dextrans in Aqueous Solution

Ingelman and Halling[1] have made measurements of sedimentation, diffusion and viscosity of fractions of dextran subjected to partial hydrolysis. On the basis of sedimentation and diffusion alone, and neglecting solvation, they concluded that the dextran particles are considerably elongated (length/thickness varying between 17 and 110).

Fessler and Ogston[2] and Ogston and Stanier[3] have shown that both the asymmetry and the solvation (effective volume) can be deduced from measurement of the sedimentation constant and any pair of: diffusion, intrinsic viscosity and the variation of sedimentation constant with concentration. It is of interest to examine Ingelman and Halling's data from this point of view.

The procedure chosen is as follows: from the sedimentation constant at zero concentration and the intrinsic viscosity (using Perrin's[4] and Mehl, Oncley and Simha's[5] relationships) sets of values of the axial ratio p, the effective volume V' ml. per gm. of unsolvated solid, and the unsolvated molecular weight M are obtained. From these quantities, values of $d(1/s)/dc$ are predicted. The values of M obtained from S_0, D_0 and $\overline{V}$ (partial specific volume), and the observed values of $d(1/s)/dc$ are then compared with the predicted values.

The values of M in every case are close to those predicted for an axial ratio of 1 and, where the data are sufficient to give reliable estimates of $d(1/s)/dc$, these indicate values of the axial ratio of less than 10.

The corresponding values of V' vary between 3 ml./gm. for $M = 14{,}000$ and 30 for $M = 3{\cdot}3 \times 10^6$, indicating considerable degrees of solvation. Kuhn and Kuhn[6] have shown that the effect of branching of a flexible chain is to reduce the volume which it occupies in solution compared with that occupied by an unbranched chain of the same total length (that is, the same molecular weight). The volumes deduced above lie between 0·17 and 0·09 of the volumes predicted by the theory of Kuhn and Kuhn for unbranched flexible chains of glucose units, and this agrees with the chemical evidence[7] in suggesting a high degree of branching.

We conclude that the data available indicate that dextran particles in solution are highly solvated and not very asymmetric, and that this view is consistent with what is known of their chemical structure.

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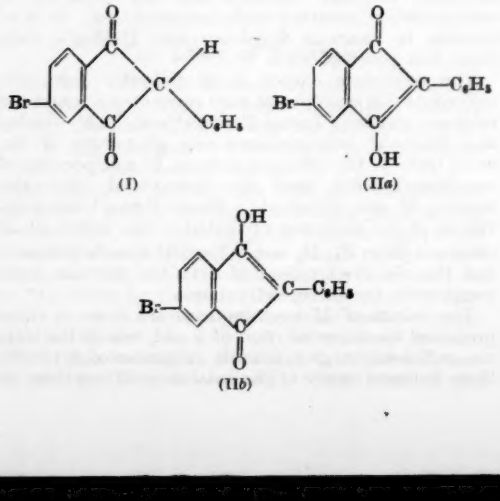
[1] Ingelman, B., and Halling, M. S., *Ark. Kem.*, **1**, 61 (1950).
[2] Fessler, J. H., and Ogston, A. G., *Trans. Farad. Soc.*, **47**, 667 (1951).
[3] Ogston, A. G., and Stanier, J. E., *Biochem. J.*, **49**, 585 (1951).
[4] Perrin, F., *J. Phys. Radium*, (7), **7**, 1 (1936).
[5] Mehl, J. W., Oncley, J. R., and Simha, R., *Science*, **92**, 132 (1940).
[6] Kuhn, W., and Kuhn, H., *Helv. Chim. Acta*, **30**, 1233 (1947).
[7] Kent, P. W., *Science*, **110**, 689 (1949).

Thermochromism and Keto-Enol Tautomerism of Solutions of 1 : 3-Diketo-2-phenyl-5-bromoindan

In connexion with the growing interest in the phenomenon of thermochromism[1], we should like to describe some experiments with 1 : 3-diketo-2-phenyl-5-bromoindan (I). In contrast to 1 : 3-diketo-2-phenylindan, which exists only in a colourless, solid form, (I) exists in a deep violet, solid form (II*a* or II*b*) and an almost colourless, solid, ketonic form (I). Koelsch[2], who discovered these forms, stated that by crystallization from non-polar solvents the white modification is obtained, and from polar solvents the violet-black modification is formed; he mentioned only acetic acid and benzene as solvents. According to our observations, dilute solutions of the violet-black form in ethyl benzoate are orange at − 10°, whereas at the boiling point of the solutions they are light-yellowish. The process is reversible and may be explained by assuming that, at high temperatures, the keto form is predominant, whereas in the cold the enol form (II*a* or II*b*) is present in greater concentration. This opens a route for the investigation of the position of the equilibrium between the keto and the enol forms in relation to temperature by the investigation of the visible spectrum.



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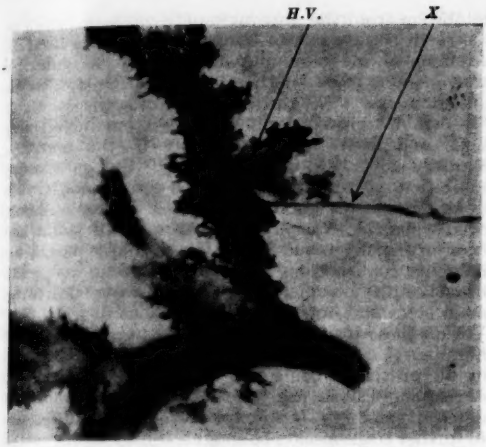
[1] Schönberg, Ismail and Asker, *J. Chem. Soc.*, 442 (1946). Hukins and Le Fèvre, *J. Chem. Soc.*, 2088 (1949). Grubb and Kistiakowsky, *J. Amer. Chem. Soc.*, **72**, 419 (1950). Theilacker, Kortüm and Friedheim, *Ber.*, **83**, 508 (1950). Bergmann, Weizmann and Fischer, *J. Amer. Chem. Soc.*, **72**, 5009 (1950). Pullman and Berthier, *Bull. Soc. Chim.*, (5), **17**, 1097 (1950). Koelsch, *J. Org. Chem.*,, **16**, 1362 (1951). Knott, *J. Chem. Soc.*, 3038 (1951). Hirshberg, Loewenthal, Bergmann and Pullman, *Bull. Soc. Chim.*, (5), **18**, 88 (1951). Schönberg, Mustafa and Asker, *J. Amer. Chem. Soc.*, **73**, 2876 (1951). Mustafa and Hilmy, *J. Chem. Soc.*, 1343 (1952).
[2] Koelsch, *J. Amer. Chem. Soc.*, **58**, 1328 (1936).

Anatomical and Physiological Evidence of Anastomosis of the Hepatic Artery and Hepatic Vein within the Mammalian Liver

That the hepatic artery sends direct branches to the hepatic vein in the livers of Amphibia has been established[1]. Several workers have reported translobular branches in mammalian livers; but the evidence is frequently indirect. Chronszczewsky[2], Braus[3] and Loeffler claim to have seen such a vessel; Elias[4] is a protagonist of the view of Chronszczewsky, whose work he has repeated; he also reports that the arterial blood gains the centre of the lobule via thin-walled capillaries which run in close apposition to the parenchyma. Seneviratne[5], using a trans-illumination technique, also supports the existence of translobular arterial vessels. Owing to technical difficulties these arterial vessels have not been shown convincingly, and their presence is not yet generally accepted.

The vessels can, however, be demonstrated by the following technique. Immediately after death the liver is washed with a slightly alkaline solution[6]. When the organ is free from blood, the portal venous system is blocked by perfusion of the portal vein with a suspension of kieselguhr in saline. 'Hycar' latex is then put into the arterial system at a pressure of about 200 mm. mercury and, afterwards, coloured neoprene is run into the hepatic vein in a retrograde direction at a pressure of 30 mm. mercury. The organ is then fixed in acid formalin, and a cast of the vascular system obtained by digestion with commercial hydrochloric acid.

The completeness of the injection varies somewhat from liver to liver. In successful preparations the arterial and hepatic venous trees are well injected, and only isolated segments of the portal venous tree appear; the sinusoids are frequently not filled, except for localized areas. On occasion, the hepatic tree has been almost fully filled from the arterial side without injection of sinusoids. This filling is achieved by means of direct arterio-venous anastomoses, one of which is shown in the accompanying photograph.



Arterio-venous anastomosis. *H.V.*, hepatic vein. *X*, anastomosing branch of the artery

In these specimens it is impossible to retain the normal relationships of the vessels, and one cannot determine the angle at which the vessels run before joining. There is no constant pattern, but the majority of the arterial vessels run into the base of small sublobular veins; they appear to be more frequent in the deeper parts of the parenchyma. Owing to distortion of the vessels by the injection technique, their size cannot be estimated with certainty, but they appear to be arterioles. Occasionally they split into a few short sinusoids before joining the hepatic venous tree. From the unbranching path taken by most of these vessels they appear to be shunts, and not concerned with the maintenance of parenchyma. They have so far been demonstrated in rats, rabbits and guinea pigs.

Supporting physiological evidence has been elicited from perfusion of isolated canine livers. Acetylcholine produces an increase in hepatic volume and a diminution of outflow when injected into the hepatic artery in amounts of 0·25–1·0 μgm.: ten to twenty times the amount is required to give a similar response if introduced into the portal vein[7]. Also, on occasion, adrenaline may give rise to swelling of the liver when put into the hepatic artery, and invariably produces a diminution of volume when put into the portal vein. The variation of the action of these drugs according to the vessel of administration is strong evidence in favour of different intrahepatic pathways of arterial and portal venous blood, especially as in each case increase of liver volume is due to reduction of outflow and not to increase of inflow, suggesting that the site of action is on the hepatic veins.

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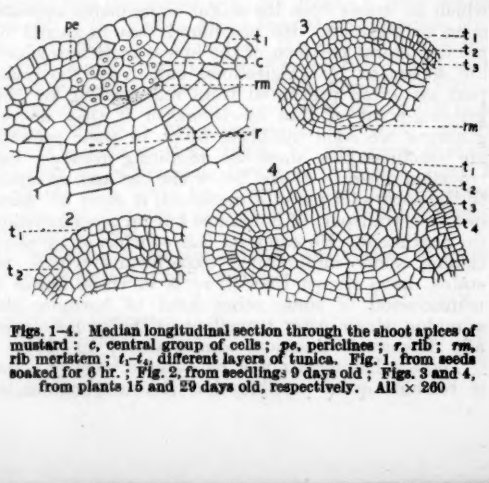
[1] Wakim, K. G., and Mann, F. C., *Anat. Rec.*, **82**, 233 (1942).
[2] Chronszczewsky, N., *Virchows Arch.*, **35**, 153 (1886).
[3] Braus, H., "Anatomie des Menschen", **2**, 321 (Berlin, Springer, 1924).
[4] Elias, H., *Amer. J. Anat.*, **85**, 379 (1949).
[5] Seneviratne, *Quart. J. Exp. Physiol.*, **35**, 77 (1949).
[6] Andrews, W. H. Horner, Maegraith, B. G., and Wenyon, C. E. M., *Ann. Trop. Med. Parasit.*, **43**, 229 (1949).
[7] Andrews, W. H. Horner, and Maegraith, B. G., *Ann. Trop. Med. Parasit.*, **45**, 255 (1952).

Organization of Shoot Apex during the Ontogeny of *Brassica campestris* L.

Our knowledge of the organization of shoot apices is confined mostly to mature plants, and there has been very little work on the ontogenetic changes occurring in them[1]. Certain interesting observations on the above topic came to light during a comparative anatomical study of vernalized and control plants[2] of mustard. Microtome sections of: (1) seeds soaked for six hours in water; (2) seedlings collected at intervals of twenty-four hours up to seven days and then on the ninth day; and (3) vegetative and reproductive apices formed fifteen and twenty-nine days after sowing were cut 13 μ thick and stained with hæmatoxylin and safranin.

The apical meristem of the resting embryo is a dome-shaped structure with a uniseriate tunica (Fig. 1) surmounting the corpus, the central cells (*c*) of which are polygonal, more or less isodiametric and deeper stained. The cells of the rib-meristem (*rm*) and the rib (*r*) converge above to this group of central cells and appear to be originating from them. These central cells could not be distinguished in seedlings more than twenty-four hours old. This type of zonation in the apical meristem is quite different from any so far observed[1,3–6]. The periclines (*pe*) present in the second layer of the apical meristem of the embryo become rarer with an advance in age, and in seedlings nine days old the tunica is biseriate (Fig. 2). The cells of the next layer now begin to show a stratified form. Occasional periclinal divisions, however, continue to occur here and shoot apices of fifteen-days-old plants show two or three layers of tunica (Fig. 3). In a reproductive shoot the tunica layers, composed of more-or-less columnar cells, increase further to three or four (Fig. 4) and the corpus appears to be replaced by vacuolating cells. One or more layers of cells below the central part of the tunica are also stratified.

There is scarcely any activity of the rib meristem for the first five days, and the growth of the epicotyl is due to a progressive elongation of rib cells. At an age of six days, however, the rib meristem becomes suddenly active and gives rise to several layers of transversely elongated cells. In seven- and nine-day-old seedlings no fresh similar cells are formed and the pre-existing ones enlarge longitudinally. Normally, it is expected that the rib meristem, once active after germination, would continue to be so, and thus its behaviour in the present case is rather interesting. In the shoot apices of fifteen-day-old plants, the



Figs. 1–4. Median longitudinal section through the shoot apices of mustard: *c*, central group of cells; *pe*, periclines; *r*, rib; *rm*, rib meristem; t_1–t_4, different layers of tunica. Fig. 1, from seeds soaked for 6 hr.; Fig. 2, from seedlings 9 days old; Figs. 3 and 4, from plants 15 and 29 days old, respectively. All × 260

rib meristem assumes a semi-circular form extending from almost one flank of the apex to the other (Fig. 3, *rm*).

Procambial strands differentiate acropetally in the apex before the leaves, which they are going to supply, arise. Similar cases have been recorded by several workers[1,4,8,10].

Variation in the number of tunica layers within the same species has been accounted for in *Garrya* by the stages of development of leaf primordia by Reeve[8,9]. I, however, failed to observe this in my materials, and so did Millington and Gunckel[6]. In mustard, the variation in the number of tunica layers appears to be related to the growth conditions of the shoot. During the vegetative phase there is scarcely any appreciable elongation of it. At the onset of the reproductive phase, the main axis grows in length very rapidly and its apex shows the maximum number of stratified layers (5–6). Majumdar[5] observes that, in shoot apices of *Heracleum*, there are 5–6 stratified layers on the flanks in contrast to only three at the apex. Here, too, the increased number on the flanks is related to the growth conditions of the plant, which possesses a "rapidly widening axis just below the apical cone without any vertical expansion". Similar positive correlation is observed in (1) *Liriodendron*[6], where there are more tunica layers in the active stage, and (2) *Tropæolum*[11], the young axillary shoot apices of which have only a uniseriate tunica in contrast to 2–3 in the main shoot.

I am grateful to Prof. B. Singh and Prof. G. P. Majumdar for their kind criticisms and suggestions.

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[1] Philipson, W. R., *Biol. Rev.*, **24**, 21 (1949).
[2] Chakravarti, S. C., *Curr. Sci.*, **19**, 319 (1950).
[3] Boke, M. H., *Amer. J. Bot.*, **28**, 656 (1941).
[4] Johnson, M. A., *Phytomorph*, **1**, 188 (1951)
[5] Majumdar, G. P., *Ann. Bot.*, N.S., **6**, 49 (1942).
[6] Millington, W. F., and Gunckel, J. E., *Amer. J. Bot.*, **37**, 326 (1950).
[7] Philipson, W. R., *J. Linn. Soc. Lond.* (Bot.), **53**, 187 (1947).
[8] Reeve, R. M., *Amer. J. Bot.*, **29**, 697 (1942).
[9] Reeve, R. M., *Amer. J. Bot.*, **35**, 65 (1948).
[10] Majumdar, G. P., *Proc. Indian Acad. Sci.*, B, **28**, 83 (1948).
[11] Ball, E., *Amer. J. Bot.*, **31**, 316 (1944).

Regeneration of the Potato Shoot Apex

Mr. I. M. Sussex[1] propounds a problem of great importance and interest, but the main conclusion which he draws from his skilful experiments appears open to question. He has found that in shoots of potato lateral portions of the apical meristem which are separated by longitudinal cuts from the main part are often prevented from regenerating by the growing-point of that meristem, or if they do regenerate are soon inhibited by it in their growth. He concludes that since the inhibiting influence has travelled down to a level below the cut and up again to the separated piece of meristem, it must be based not on a transport of hormones but on a competition for nutriment. He supports this conclusion by mentioning some unpublished experiments which, he states, have shown that there is in these apices a transmission of some other kind of hormone-like stimulus which, after travelling in the morphologically downward direction, cannot travel up again.

These other results will be awaited eagerly; but it remains quite possible that the transmission of inhibition from the growing-points of these apices is based on a transport of hormones, since one kind of stimulus or influence may follow different rules of transmission from another, even if both are based on hormones. Thus in shoot systems the stimulus for cambial growth, which comes from developing buds and leaves, travels strictly in the morphologically downward direction only[2]. But correlative inhibition, coming from the same source, can travel down one shoot and up another orthotropic shoot, even when the transpiration stream in the latter has been artificially reversed[3]. Also, in many plants an influence coming from the main apical bud keeps the branches plagiotropic, and this must travel down the main stem and out along the branches to their tips. Yet all these transmissions are based on transport of hormone; and, indeed, the first stage is the same in all of them, being the formation of auxin by developing leaves near the apex and its transport down the stem[4–8]. If an explanation of the difference in further transmission be sought, it may be suggested that the cambium is stimulated to grow by the descending auxin itself, whereas the other two effects depend on other substances which can be transported upwards as well as downwards and are formed either from the descending auxin, by modification of its molecule, or as a result of its action[9]. Similarly, there may be different transmissions within the apical bud also.

It may also be remarked that although Mr. Sussex emphasizes the fact that the lateral pieces of meristem which he isolated by vertical cuts were either prevented by the growing-point from regenerating at all, or else were afterwards inhibited by it, it seems of equal interest that some of them did regenerate to form buds with two or three leaves, so that these pieces must have been partially released from inhibition. In this respect his results are rather similar to those of experiments on *Lupinus albus* in which, for another purpose, we isolated the youngest leaf or the presumptive area of the next leaf due to arise, or of the next but one, by similar vertical cuts[10]. For in many of these experiments, in which enough apical tissue was left on the isolated piece axillary to the isolated leaf, a bud was formed from this tissue, although neighbouring leaves of the same seedlings had no axillary buds. These buds grew quite strongly, so that they must have been released from inhibition nearly completely.

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[1] Sussex, I. M., *Nature*, **170**, 755 (1952).
[2] Jost, L., *Bot. Z.*, **49**, 485 (1891); **51**, 89 (1893).
[3] Snow, R., *New Phytol.*, **36**, 286 (1937).
[4] Snow, R., *New Phytol.*, **34**, 347 (1935).
[5] Söding, H., *J. wiss. Bot.*, **84**, 639 (1937).
[6] Thimann, K. V., and Skoog, F., *Proc. Roy. Soc.*, B, **114**, 317 (1934).
[7] Münch, E., *J. wiss. Bot.*, **86**, 581 (1938).
[8] Snow, R., *New Phytol.*, **44**, 110 (1945).
[9] Snow, R., *New Phytol.*, **39**, 177 (1940).
[10] Snow, M., and Snow, R., *Phil. Trans. Roy. Soc.*, B, **221**, 26 and fig. 14 (1931).

While I agree that there is much justice in the comments on my communication[1], the main fact which needs emphasis at this stage is that we are still very much in the dark concerning the roles of hormones and general nutrients in growth and morphogenesis at the shoot apex.

Fig. 1 of my communication showed in plan a potato shoot apex in which a small lateral panel *a* had been isolated from the remainder of the apical meristem *A* by a single vertical incision which penetrated all the meristematic cell layers and just into the differentiating sub-apical region. On further growth of such shoots the panel *a* usually failed to regenerate, remaining totally inhibited, although its cells retained their embryonic appearance. The incision was considered to prevent direct hormonal inhibition of the panel *a* by the larger part of the apical meristem; but the two separated parts of the apical meristem would still be able to compete with one another for a share of the available nutrients in the sub-apical region. The further growth of each would be a measure of its ability to grow under such conditions of competition. The results have been described (*loc. cit.*).

In support of this hypothesis, further experiments in which the incision was 4–5 mm. deep were carried out. Such incisions penetrated deeply into the maturing zone of the shoot, where nutrients may be expected to be localized in the vascular tissue. In such shoots the sub-apical nutritional competition between the separated parts of the apical meristem is eliminated, but it is still possible for substances to pass downwards in the stem from *A*, below the incision, and upwards into the panel *a*, that is, hormonal correlative inhibition of the panel *a* would still be possible.

Three types of deep incisions were made: (1) vertical, (2) undercutting the panel *a*, (3) undercutting the remainder of the apical meristem *A*. By such sloping incisions it was possible to provide either of the separated parts of the meristem with increased amounts of nutrients derived from a greater relative area of the mature shoot.

In each treatment eight shoots were used, and the cut surfaces were prevented from regrafting by placing a fragment of mica in each incision. The average number of leaves on the lateral panel *a* and the main apex *A* in each treatment after six days is presented in summary form in the accompanying table.

(1) Incision vertical		(2) Incision undercutting *a*		(3) Incision undercutting *A*	
a	*A*	*a*	*A*	*a*	*A*
2·9	4·3	0·4	3·9	2·9	1·5

In treatment 1, all eight of the lateral panels *a* regenerated completely, and the results obtained with a deep incision thus differ sharply from those following a shallow incision when regeneration is infrequent. In treatment 2, the strongly growing main apex *A* of several shoots was excised after six days, leaving only the inhibited panel *a*, which then usually began to grow and formed two to three leaves in the following six days. In treatment 3 it is noteworthy that the growth of the larger meristematic region *A* has been 'inhibited' by the smaller panel *a*.

In these treatments the more rapidly growing meristem became considerably enlarged, even if it was initially very small, and gave rise to leaves which were much larger than those on the slow-growing shoot. As a result of these experiments it is felt that the inhibition of growth in lateral parts of the apical meristem is achieved in large part by a depletion of nutrients in the immediate vicinity of the inhibited meristems. Growth hormones may well be of importance in such inhibition but would appear to have an indirect effect, perhaps acting in the mobilization of nutrients towards the more actively growing regions of the meristem.

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[1] Sussex, I. M., *Nature*, **170**, 755 (1952).

Amœba discoides recorded for Milngavie, Dunbartonshire

The inoculation material for our stock cultures of *Amœba* at Notre Dame was procured either from Killarney or Milngavie. From the outset each culture was numbered and its subsequent history entered in a field-book, so that we know the origin and history of any material given to the various universities and schools which have asked for it during the past thirty years. Early on, it was suspected that culture 14 was different from the other cultures, but many researches were pressing, and I had not time to look into the matter. The culture accumulated and sub-cultures were made. In 1949 and 1950 I devoted time to the examination of the cytoplasmic movements of the individual amœbæ and concluded that they were not those characteristic of *A. proteus*. In 1952 I completed the investigation. The creatures in culture 14 are *Amœba discoides*, the life-history of which has been worked out by Sister Carmela Hayes[1]. Up to date, the species has been recorded from the neighbourhood of Oxford and Grimsby.

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[1] *Quart. J. Micro. Sci.*, **80**, 459 (1946).

Flight-tone and Wing-stroke Frequency of Insects

In his interesting article, Dr. O. Sotavalta[1] discusses the estimation of the wing-stroke frequency of insects by their audible note. This method is older than he suggests. ". . . and I took coach, having first discoursed with Mr. Hooke a little, whom we met in the streete, about the nature of sounds, and he did make me understand the nature of musicall sounds made by strings, mighty prettily; and told me that having come to a certain number of vibrations proper to make any tone, he is able to tell how many strokes a fly makes with her wings (those flies that hum in their flying) by the note that it answers to in musique during their flying. That, I suppose, is a little too refined; but his discourse in general of sound was mighty fine." (Samuel Pepys, August 8, 1666.)

Doubtless Pepys would have been pleased to know that his criticism had been met.

C. F. A. Pantin

Trinity College,
Cambridge.
Dec. 22.

[1] Sotavalta, O., *Nature*, **170**, 1057 (1952).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Saturday, January 31

NUTRITION SOCIETY, SCOTTISH GROUP (in the Anatomy Lecture Theatre, Marischal College, Aberdeen), at 1.20 p.m.—Conference on "The Psychology of Eating".

Monday, February 2

UNIVERSITY OF LONDON (at the London School of Economics and Political Science, Houghton Street, Aldwych, London, W.C.2), at 5 p.m.—Prof. H. Lauterpacht: "The Revision of the Laws of War".*

SOCIETY OF ENGINEERS (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. G. N. Swayne: Presidential Address.

SOCIETY OF CHEMICAL INDUSTRY, LONDON SECTION (joint meeting with the PLASTICS AND POLYMER GROUP, at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Dr. D. Traill: "The New Wool-like Fibres".

ROYAL INSTITUTE OF CHEMISTRY, LONDON SECTION (joint meeting with the ALEMBIC CLUB, in the Physical Chemical Laboratory, The University, Oxford), at 8 p.m.—Symposium on "Research in Industry compared with Research in Universities".

Tuesday, February 3

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 1.15 p.m.—Dr. E. Wiesenberg: "The Dead Sea Scrolls".*

Wednesday, February 4

BRITISH PSYCHOLOGICAL SOCIETY, INDUSTRIAL SECTION (in Room 105, London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 1 p.m.—Mr. R. Marriott: "Some Problems in Attitude Survey Methods".

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Mr. I. D. Wratten: "A Century of Photography" (Peter Le Neve Foster Lecture).

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Scientific Papers.

UNIVERSITY OF LONDON (at Bedford College, Regent's Park, London, N.W.1), at 5.15 p.m.—Mr. G. de Q. Robin: "The Recent Antarctic Expedition" ("Recent Exploration and Discovery", 1).* (Further Lectures on February 11 and 17.)

UNIVERSITY OF LONDON (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Dr. W. J. Gibbs: "High Frequency Machines—Inductor Generators and Couplings".* (Further Lectures on February 18 and March 4.)

Thursday, February 5

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 1.15 p.m.—Dr. K. A. Kermack: "The Origin of Mammals".*

CHEMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 2.30 p.m. and 7.30 p.m.—Symposium on "Acetylene Chemistry".

SOCIETY OF CHEMICAL INDUSTRY, CORROSION GROUP (joint meeting with the NOTTINGHAM SECTION of the S.C.I., at the Gas Showrooms, Parliament Street, Nottingham), at 7.15 p.m.—Dr. J. C. Hudson and Mr. J. F. Stanners: "Atmospheric Corrosion and Atmospheric Pollution".

Friday, February 6

PHYSICAL SOCIETY (in the Department of Meteorology, Imperial College of Science and Technology, Exhibition Road, London, S.W.7), at 2.15 p.m.—Discussion on "Physics of the Upper Atmosphere".*

ROYAL INSTITUTE OF PHILOSOPHY (at University Hall, 14 Gordon Square, London, W.C.1), at 5.30 p.m.—Prof. J. N. Findlay: "Wittgenstein's Philosophical Studies". (Further Lecture on February 12.)

SOCIETY OF DYERS AND COLOURISTS, LONDON SECTION (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 6 p.m.—Mr. F. Ward: "Methods and Principles of Textile Fireproofing".

SOCIETY OF CHEMICAL INDUSTRY, PLASTICS AND POLYMER GROUP (joint meeting with the MANCHESTER SECTION, in the Chemistry Lecture Theatre, The University, Manchester), at 6.30 p.m.—Mr. J. R. Whinfield: "Textile Fibres—Variations on some Familiar Themes" (Jubilee Memorial Lecture).

SOCIETY OF COSMETIC CHEMISTS OF GREAT BRITAIN (in the Conference Room, British Colour Council, 13 Portman Square, London, W.1), at 7 p.m.—Dr. J. G. Fife: "Patents".*

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Dr. Henry Seligman: "Production and Uses of Radioisotopes".

Saturday, February 7

LONDON COUNTY COUNCIL (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 3.30 p.m.—Dr. Hurustiati Subandrio: "The Toradja—Peoples of Central Celebes".*

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT DIRECTOR (with a good degree, preferably with first-class honours, in natural science, including chemistry or physics) OF EXAMINATIONS IN SCIENCE—The Secretary, Civil Service Commission, 6 Burlington Gardens, London, W.1, quoting No. 4183/53 (February 7).

PHYSICIST or ELECTRONIC ENGINEER to assist in research and clinical work on the applications of physics to diagnostic radiology, and a PHYSICIST to assist in work on the medical applications of radioactive isotopes—The Secretary, Institute of Cancer Research, Royal Cancer Hospital, Fulham Road, London, S.W.3 (February 7).

PHYSIOLOGIST (with a good honours degree in physiology, or equivalent qualification, and research experience preferably involving the perfusion of isolated organs) for research on the bovine udder—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, quoting Ref. 53/3 (February 7).

BIOCHEMIST (principal or senior grade)—The Secretary, South Worcestershire Hospital Management Committee, Royal Infirmary, Worcester (February 9).

LECTURER IN PHYSIOLOGY—The Registrar, King's College, Strand, London, W.C.2 (February 14).

PRINCIPAL OF THE EAST RIDING INSTITUTE OF AGRICULTURE, Bishop Burton—The Chief Education Officer, County Hall, Beverley, Yorks (February 14).

SUPERINTENDING SCIENTIST AT THE LONG RANGE WEAPONS ESTABLISHMENT, Salisbury, Australia, for the direction of research and development work concerned mainly with methods of investigating the behaviour and performance of guided missiles and with flight research on guided missiles—The Senior Representative, Department of Supply, Canberra House, 87 Jermyn Street, London, S.W.1 (February 14).

SENIOR RESEARCH FELLOW IN THE DEPARTMENTS OF ECONOMICS and PACIFIC HISTORY, Australian National University, Canberra—The Secretary, London Office of the Australian National University, 27 Russell Square, London, W.C.1 (February 15).

ASSISTANT INSTRUCTOR IN PHYSICS AND APPLIED MATHEMATICS at the Ethiopian Air Force Training School—The Educational Adviser, Imperial Ethiopian Embassy, 17 Princes Gate, London, S.W.7 (February 16).

ASSISTANT LECTURER OR LECTURER IN THE DEPARTMENT OF CIVIL ENGINEERING—The Registrar, The University, Liverpool (February 23).

SENIOR LECTURER OR LECTURER IN MATHEMATICAL STATISTICS, and LECTURERS IN PSYCHOLOGY, VETERINARY ANATOMY, VETERINARY PHYSIOLOGY and VETERINARY FARM CLINIC, at the University of Sydney—The Secretary, Association of Universities of the Commonwealth, 5 Gordon Square, London, W.C.1 (March 7).

EDUCATIONAL PSYCHOLOGIST FOR CHILD GUIDANCE DEPARTMENT—The Medical Officer of Health, Civic Centre, Southampton.

ENGINEERS and PHYSICISTS (particularly with electronics) in (*a*) SENIOR SCIENTIFIC OFFICER and SCIENTIFIC OFFICER grades (Ref. A.246/52A) and (*b*) SENIOR EXPERIMENTAL OFFICER, EXPERIMENTAL OFFICER and ASSISTANT EXPERIMENTAL OFFICER grades (Ref. A.247/52A) in Admiralty Experimental Establishments in London, Portsmouth, Weymouth areas, and Scotland—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting the appropriate Ref. No.

EXPERIMENTAL OFFICERS IN THE GUIDED WEAPONS DEPARTMENT, Royal Aircraft Establishment, Farnborough, for work on design, development and performance of new weapons and associated guidance and control systems; instrumentation of flight trials and investigations of trials results—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting D.508/52A.

GRADUATE (with honours degree in chemistry or metallurgy) to undertake research in the methods of preventing corrosion of iron and steel—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, endorsed 'Corrosion'.

GRADUATE (with good honours degree in chemistry or metallurgy) to carry out research into chemical reactions of interest in iron and steel making—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, endorsed 'Slags'.

HEAD STATISTICIAN—The Director, British Boot, Shoe and Allied Trades Research Association, Satra House, Kettering.

LECTURER or ASSISTANT LECTURER IN INORGANIC CHEMISTRY—The Registrar, The University, Nottingham.

MINING GEOLOGIST (with a first- or second-class honours degree in geology, or higher qualification) in the Local Civil Service of the Gold Coast, to undertake geological mapping in the field and underground—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting CDE.105/13/03.

PHYSICAL METALLURGIST (university degree or equivalent essential) to carry out research on the ageing of mild steel (location: Sheffield)—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, endorsed 'Ageing of Steel'.

PHYSICIST interested in mechanics (with an honours degree or equivalent) for study and instrumentation of felting machines—The Director, British Hat and Allied Feltmakers Research Association, Stanley House, Manchester Road, Fairfield, Droylsden, Manchester.

SCIENTIFIC OFFICER (Grade II) IN THE OPERATIONAL RESEARCH DIVISION at Euston Square, to undertake research on a wide variety of railway subjects—The Director of Research, Railway Executive, 222 Marylebone Road, London, N.W.1.

SCIENTIFIC OFFICER or SENIOR SCIENTIFIC OFFICER (with an honours degree or its equivalent) for the determination of solidification sequences in cast iron by temperature gradient measurements, as part of an investigation on the soundness of iron castings—The British Cast Iron Research Association, Alvechurch, Birmingham.

SENIOR SCIENTIFIC OFFICERS (with at least a second-class honours degree in chemistry or metallurgy, or equivalent, and three years postgraduate research experience) at Sellafield: (Ref. 404) for research in physical and inorganic chemistry (experience in fluorine chemistry, ion exchange, and radiochemical techniques desirable), and (Ref. 405) for research in metallurgy of radioactive materials—The Ministry of Supply, Division of, Atomic Energy (Production), Risley, Warrington, Lancs, quoting the appropriate Ref. No.

TUTORIAL ASSISTANT (with a good honours degree in mathematics, including statistics) IN THE DEPARTMENT OF ECONOMICS, to assist in the first year in statistical research, with a view to appointment as Assistant Lecturer in the field of Statistics and Mathematical Economics—The Registrar, The University, Nottingham.